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SHIP STRUCTURES RESEARCH IN CANADA

THE DEVELOPMENT OF A PRACTICAL PROGRAM AND MANAGEMENT APPROACH

MAY 1990

Report of a Study Executed under the Visiting Experts Program of the Transportation Development Centre Policy and Coordination Group Transport Canada

by

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Un sommaire en français de ce rapport est inclus avant la table des matières.

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16. Abstract

In light of growing concern about the future focus of ship structures research in Canada, a study was performed to develop a ship structures research program and propose an organization to put this in place. The study includes a review of international concerns regarding ship structures and a review of Canadian needs, based on a literature search and a series of interviews.

Research motivators are reviewed in the Canadian context and a program of ship research activity is developed based on perceived priorities among Canadian end users. The program is divided into priorities and national as well as specific user group interests. Descriptions of the elements of a structures program are provided.

Finally, a review of organizational needs is made, and, following a review of systems in place in the UK and USA, a proposal is made based on the formation of a new subcommittee of the Marine Advisory Board of Transport Canada.

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16. Résumé

S'inscrivant dans le processus de redéfinition de l'avenir de la recherche sur la construction navale au Canada, cette étude avait pour but de poser les balises d'une stratégie de R&D et de proposer une structure organisationnelle adaptée aux besoins du programme. A la lumière des informations recueillies dans diverses publications et au cours d'une série d'entrevues, les auteurs font une revue des grands axes de la R&D en construction navale à travers le monde et des besoins du Canada dans ce domaine.

L'utilité d'un tel programme est envisagée dans l'optique du contexte canadien et les auteurs proposent une stratégie de recherche fondée sur les priorités de la clientèle canadienne. Le programme est structuré en fonction des priorités, des besoins nationaux et des intérêts de la clientèle. Les auteurs donnent des descriptions des divers éléments qui composent le programme proposé.

Enfin, les auteurs font une revue des besoins organisationnels du programme proposé et, après un tour d'horizon des programmes implantés au Royaume-Uni et aux Etats-Unis, proposent la création d'un sous-comité qui serait rattaché au Conseil consultatif du transport maritime du Canada.

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PREFACE

The work performed in the study reported herein was initiated by the author's concern for the future of Canadian ship research in general, and ship structures research in particular. It appeared that there was capability and a need, but that in the absence of focus, the ability to maintain domestic capability and maintain international recognition was in jeopardy. It was also clear that in the face of diminishing research dollars, efficiencies in management and execution were required. The project afforded the opportunity to discuss the issues and recommend solutions.

It was observed at the commencement that some work in the area had been commissioned by NRC's Institute for Marine Dynamics, that was directly relevant, and the author drew heavily on this allowing him to slightly re-focus his study to provide a logical follow- on to the previous work, and avoid duplication. It is somewhat ironic that this very situation is a reflection of one of the problems addressed - lack of information flow and potential duplication.
The program was carried out as part of the Visiting Experts Program at the Transportation Development Centre. As such, special attention has been paid to the research areas of interest to TDC. In addition, it was recognized that part of the purpose of the program is to have outside specialists resident in TDC. This was an advantage, providing access to a fine library and some concerned research managers.

The author wishes to acknowledge the many people who provided written or verbal input to this study, and who took the time to respond to the author's telephone interviews. In particular the staff at TDC are thanked for their input and comments.

EXECUTIVE SUMMARY

A project was carried out under the "Visiting Experts" program at the Transportation Development Centre (TDC) in Montreal, to develop a program and strategy for future ship structures research in Canada. The project was motivated by the increased effort by Canada to participate in international ship structures activity, examples of which include the NRC Institute of Marine Dynamics' (IMD) offer to host a forthcoming International Ship Structures Congress (ISSC), and the Navy's participation in NATO tri-partite groups in ship structures research.

Drawing heavily on a report prepared for the IMD, the study reviewed the current interests and concerns in ship structures research internationally, and reviewed the current programs and activities in the field in Canada. An assessment of the capabilities in the country, including analytical, full scale and experimental facilities concluded that Canada had a modest capability, that some of the work being performed was of international significance, and that, while there are above average opportunities for full scale experiments on ships, the laboratory facilities in the country are modest by world standards.

The need for ship structures research in Canada is reviewed,with emphasis on the users of the results and the motivation for the research. The specific requirements of the various Canadian fleet operators, designers, shipbuilders and regulators are examined, and the needs of the researchers themselves are discussed. Non- technical needs including the need for coordination, information dissemination, peer review and quality checks are discussed. It is noted that too much activity in Canada duplicates past efforts or activity elsewhere, and that there is a particular problem with the communication of Navy research activity, and the dissemination of information.

Program needs are identified by user group, and the level of interest estimated, leading to the priorizing of a Canadian ship structures program. This program is set out in some detail, with separate identification of projects that are of interest to only one group (e.g. Coast Guard, Navy), and those that are of interest to a wide group of users. These latter form the national ship structures research program.

The program is divided into first and second priorities, and research topics under each technical area are defined. For each program item, a brief description of the type of research, the justification and objectives is provided, as well as an indication of the national or international significance of the work. It is evident that there is scope for a worthwhile program in Canada that utilises the available talent, addresses both Canadian and international needs, and is accommodated within a reasonable budget.

The final section of the report discusses possible organization options for managing the research program. Since many of the problems extant are associated with lack of communication and focus, this aspect is considered to be a prime consideration. Reviews of the UK and US approaches are made, and a proposal is put forward with options discussed. The preferred organization is one in which a new Committee of the Marine Advisory Board is formed which manages the structures program, and is financed to administer as well as fund the research. Members would be drawn from industry, universities and government and would rotate every two years. The only permanent staff would be a secretariat which would be staffed by NRC.

The conclusion of the work is that Canada has a need for ship structures research, and has the capability to address both Canadian and internationally significant issues in the field. A practical and meaningful structures research progam is presented. The management of this program, will include the planning, execution, review, monitoring and quality control of programs as well as coordination with other groups, and information dissemination. The formation of a proposed government/industry/university body that is funded at a modest level, is of fundamental importance to the success of the research program and should be put in place as soon as practicable.

SOMMAIRE

Ce projet qui s' inscrivait dans le cadre des activités du Centre de développement des transports (CDT), avait pour but de jeter les bases d'une stratégie de recherche dans le domaine de la construction navale au Canada, et d'appuyer la politique du gouvernement visant à accroître la participation candienne aux activités internationales de l'industrie de la construction navale, activités telles que le prochain "International Ship Structures Congress" (Congrès international de la construction navale) qui pourrait être organisé sous l'égide de l'Institut de dynamique marine du CNR at la participation de l'OTAN sur la construction navale.

S'inspirant largement d'un compte rendu préparé par l'Institut de dynamique marine, l'étude fait une revue des programmes et activités actuellement en cours au Canada. Une évaluation de l'infrastructure nationale de R & D, y compris les installations de recherche théoretique ou analytique, les laboratoires d'essai et les installations d'expérimentation en vraie grandeur, a révélé que le Canada dispose de moyens modestes mais que certains des projets réalisés au pays sont d'envergure internationale et enfin que, si l'infrastructure d'expérimentation en vraie grandeur est supérieur à la moyenne, celle dont disposent les laboratoires est modeste comparativement aux autres pays.

L'auteur passe en revue les besoins du Canada en matière de recherche dans le domaine de la construction navale en mettant l'accent sur les priorités de la clientèle et l'utilité d'une telle recherche. Il se penche sur les besoins particuliers des sociétés de transport maritime, des chantiers navals et des organismes de réglementation, de même que sur les besoins des chercheurs eux-mêmes. Il fait également état des besoins non techniques, notamment en matière de coordination des recherches, de diffusion des résultats, d'examen critique des travaux par les pairs et de contrôle de la qualité. Enfin, il souligne la tendance du Canada à répéter ce qui s'est fait auparavant ou ce qui se fait allieurs, et les difficultés d'access à l'information sur les activités de recherche de la Marine et les problèmes de diffusion.

Les besoins en matière de R & D sont définis selon la catégorie d'utilisateur considéré et le degré d'intérêt estimé; cet exercice débouche sur l'establissement d'un ordre des priorités pour le programme canadien de R & D en matière de construction navale. Une description relativement détaillée des activités du programme est proposée, deux groupes de projets étant constitués: projets de R & D axés sur les intérêts d'un seul groupe (Garde côtière canadienne, Marine) et ceux axés sur les intérêts d'une vaste clientèle. Le deuxième constitue le programme national de recherche sur la construction navale envisagé.

Le programme proposé distingue deux ordres de priorités, et les sujets de recherche sont classés par domaine technique. Chaque projet fait l'objet d'une brève description du type de recherche envisagé, d'une indication de l'importance du travail à l'échelle nationale ou internationale. Il ressort de cette étude que le Canada a besoin d'un solide programme de R & D qui saura rallier toutes les compétences disponibles et répondre aux besoins nationaux et internationaux, dans les limites d'un budget raisonnable.

Dans la dernière partie du compte rendu, l'auteur étude les structures organisationnelles qui seraient le mieux adaptés à la gestion d'un tel programme. Par ailleurs, comme un grand nombre des facteurs qui font obstacle à la R & D en matière de construction navale sont associés à des problèmes de communication et de coordination, ces deux critères revêtent une importance cruciale dans l'élaboration du programme. Le rapport fait état des approches adoptées au Royaume-Uni at aux États-Unis et propose une approche adapté au contexte canadien avec diverses options possibles. Selon le type d'organisation préconisé, un nouveau Comité du Conseil consultatif du transport maritime serait mis sur pied pour assurer la gestion du programme de R & D proposé. Ce Comité serait doté d'un budget d'administration at de financement des projets de recherche. Ses membres seraient recrutés dans les milieux industriel, académique et gouvernemental et auraient un mandat de deux ans. Le seul personnel permanent serait celui affecté au secrétariat doté par le CNR.

La conclusion de cette étude est que le Canada a besoin d'un programme de recherche sur la construction navale et est en mesure d'occuper d'importants créneaux de R & D tant à l'échelle nationale qu'internationale. L'auteur propose pour cela la création d'un programme national de recherche axé sur des projets pratiques et utiles. L'administration de ce programme comprendra les fonctions de planification, d'exécution, de revue, de supervision et de conuôle de la diffusion de l'information. La création d'un Comité tripartite réunissant des représentants du gouvernement, de l'industrie et des milieux universitaires et qui serait doté d'un budget modeste, est d'une importance capitale pour le succès du programme de recherche. Ce Comité devra être créé le plus tôt possible.

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GLOSSARY OF ABBREVIATIONS, ACRONYMS AND SYMBOLS

ABS	American Bureau of Shipping
ABC 36	NATO Working Group (America, Britain, Canada) on ship structures.
ACV	Air Cushion Vehicle
BSRA	British Ship Research Association
CASPPR	Canadian Arctic Shipping Pollution Prevention Regulations
CANMET	Canadian Centre for Mineral and Energy Technology
CCG	Canadian Coast Guard
CMIA	Canadian Marine Industries Association (Succeeded CSSRA)
CMS	Committee on Marine Structures
COGLA	Canadian Oil and Gas Lands Administration
CRAD	Chief of Research and Development (Department of National Defence)
CSA	Canadian Shipowners' Association
CSA	Canadian Standards Association
CSSRA	Canadian Shipbuilders and Shiprepairers Association (now CMIA)
C-CORE	Centre for Cold Oceans Research and Engineering
C-FER	Centre for Frontier Engineering and Researech
CPF	Canadian Patrol Frigate
DFO	Department of Fisheries and Oceans
DHRDC	Defence Hydromechanics Research and Development Committee
DND	Department of National Defence
DREA	Defence Research Establishment Atlantic
DRES	Defence Research Establishment Suffield
DREP	Defence Research Establishment Pacific
DREs	Defence Research Establishments
DPW	Department of Public Works
FE	Finite Element
FRP	Fibre Reinforced Polymers
GRP	Glass Reinforced Plastic
HTS	High Tensile Steel
HSLA	High Strength, Low Alloy (steel)
IMD	Institute for Marine Dynamics
IMO	International Maritime Organisation
ISSC	International Ship and Offshore Structures Congress
MarAd	The US Maritime Administration
MCM	Minecountermeasures
MUN	Memorial University of Newfoundland
NABST	National Advisory Board on Science and Technology
NAVAIDS	Navigational Aids (Buoys)
NAWS	A hull monitoring system produced by German and Milne Inc.
NDHQ	National Defence Headquarters
NETE	Naval Engineering Test Establishment
NRC	National Research Council (US and Canada)
NSERC	National Science and Engineering Council
NTCL	Northern Transportation Company Limited

GLOSSARY OF ABBREVIATIONS, ACRONYMS AND SYMBOLS (Cont'd)

QT	Quenched and Tempered (steels)
RCMP	Royal Canadian Mounted Police
RINA	The Royal Institution of Naval Architects
RoRo	Roll-on, Roll- Off (Ship loading type)
SAR	Search and Rescue
SCC	Science Council of Canada
SES	Surface Effect Ship
SNAME	Society of Naval Architects and marine Engineers
SSC	Ship Structures Committee
SSSC	Ship Structures Subcommittee
SWATH	Small Waterplane Area - Twin Hull
TDC	Transportation Development Centre
TMCP	Thermo-mechanically Controlled Precipitation (steels)
TUNS	Technical University of Nova Scotia
UBC	University of British Columbia
VAST	"Vibration And STrength" -A Linear Finite Element Code

PART 1 INTRODUCTION

1.1 BACKGROUND AND OBJECTIVE

The objective of the work undertaken under the VISITING EXPERTS program at the Transportation Development Centre (TDC) and reported herein was to review Canada's capability and interests in ship structures research and technology development, and to formulate a program and an organizational structure to focus this effort. While this review was intended to be national in scope, it was also planned to emphasize the particular programs of interest to TDC.

The motivation for the project arose in the light of the following:

- NRC's Institute for Marine Dynamics (IMD) has offered to host an upcoming meeting of the International Ship and Offshore Structures Congress (ISSC). This is the most prestigious assembly of ship structures researchers.
- The Navy has joined an International group - ABC 36, on structures.
- Research in hull structural strength for icebreakers, associated with the update of the CASPPR, is winding down.
- Government budget constraints on R and D continue.

With this in mind, it was the intention in this project to objectively assess what, if any, ship structures research and development program should be pursued in Canada, given our capabilities, needs and resources, and to propose a mechanism for this to become more focused, thereby more efficient in funding, and, perhaps, in so doing, of greater benefit to all concerned. It was also recognized that a possible outcome of the work would be a proposed reduction in either the total structures effort, or in the number and variety of programs being pursued.

It is noted at the outset that there is clearly a general feeling among the involved community of the necessity for a review of some kind. Reference (1) * was produced for IMD and notes some of the problems in our structures research, including overlap, quality control and lack of dissemination of information. This reference has been of value in the review stage, and the conclusions from the main report are given in Table 1.1. DND also recently saw the need for a review of testing facilities in Canada (2), and this report has also been a useful source.

* Numbers in brackets designate references listed at the end of the report

TABLE 1.1

DEFICIENCIES IN PRESENT SHIP STRUCTURES RESEARCH IN CANADA

GOVERNMENT R & D NOT INTEGRATED

(BASIC THROUGH APPLIED TO IMPLEMENTATION: INFORMATION NOT FLOWING)

LACK OF FEEDBACK FROM USERS TO DRIVE R AND D NEEDS

NOT ALWAYS AWARE OF OR USING STATE-OF-THE-ART KNOWLEDGE

DUPLICATION OF EFFORT

LEVEL OF FUNDING TOO LOW TO ADDRESS ALL AREAS OF CONCERN ADEQUATELY

QUALITY CHECKS ON THE RESEARCH LACKING

LACK OF NATIONAL DATA BASE

LACK OF FORMAL REVIEW PROCESS

1.2 ASSUMPTIONS AND CONSTRAINTS

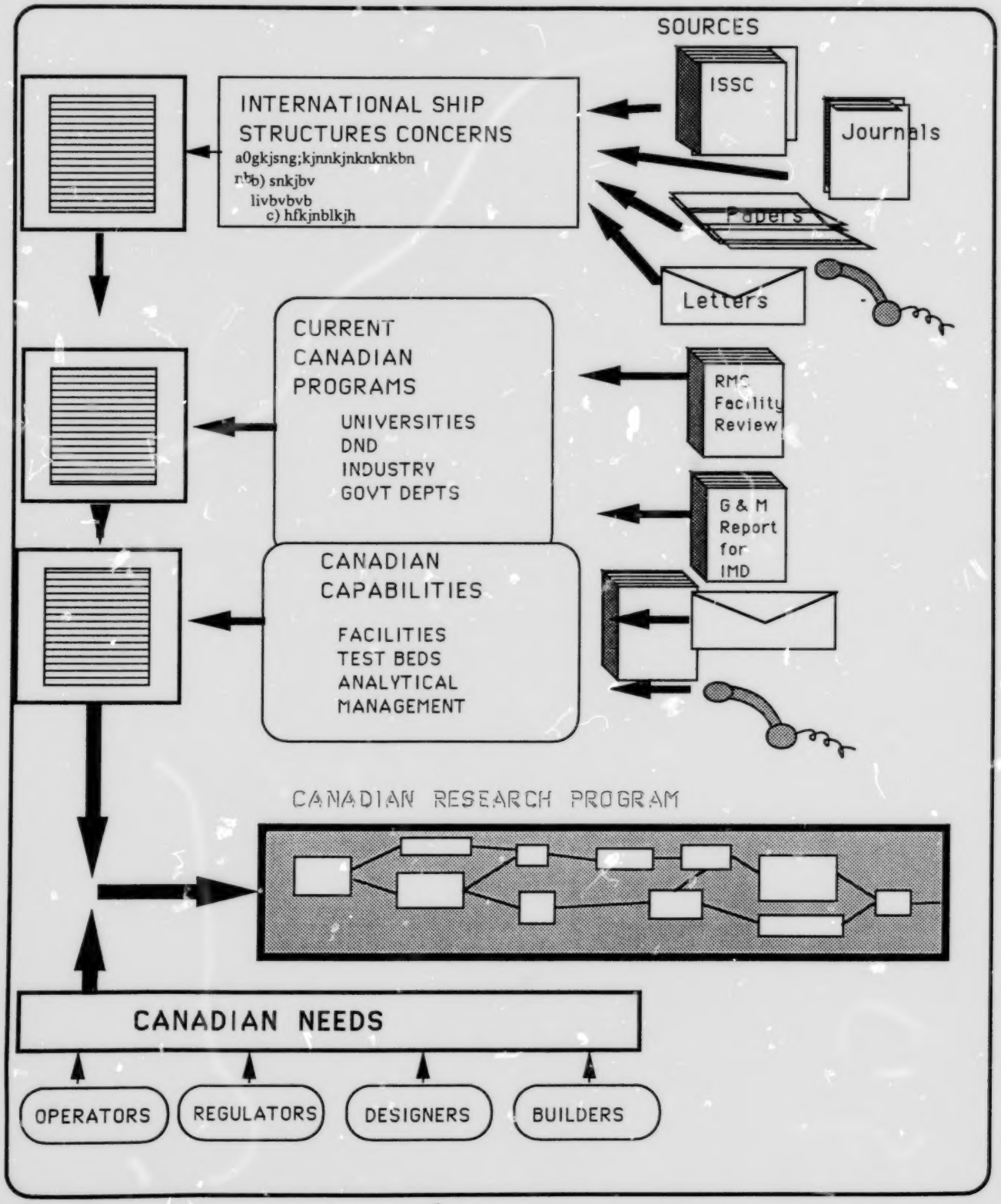
One constraint that was obvious from the outset was associated with the fact that this work was being undertaken by a consultant - a contractor who operates in the subject field. While it is essential that a study such as this be undertaken by someone who has knowledge in the field, it is a symptom of one of the problems in this country that this very action leads others to be reticent in providing information. While some such reticence was experienced, the author is pleased to relate that he obtained a great deal of cooperation in most cases and is grateful for the input of his colleagues in the industry. However, it is a fact that there is a pool of talent in the country that is fragmented and often in conflict for business or other reasons. We have in essence a spirit of *competition* and not necessarily of *cooperation*. This will be addressed later.

The project was undertaken over a period of some 12 weeks, and was constrained in both time and money such that interviews and discussions were undertaken by telephone. The views of a great many people were solicited (see list in Appendix A), and compiled. Valuable input has been received from DND and TDC in response to a preliminary draft report, and has been incorporated herein. Nevertheless, some of the input to the program development is subjective and is based on the author's observations. There is therefore scope for disagreement on program items and priorities. The author would encourage such debate, and hopes only to have provided a document around which to focus such discussion.

The study does not consciously distinguish between 'research','development' and even 'engineering' as stages in implementing technology. The term ' structures R & D' is loosely used to embrace 'structures technology development', and the purist reader is asked to forgive this. As discussed elsewhere, the somewhat artificial distinction of these stages for (Government) Fiscal reasons is perhaps one cause for the first deficiency (integration) noted in Figure 1.1.

The premise under which the program has been developed is that we in Canada must maintain a base program of technology development in ship structures and that such a program must reflect our strengths (capabilities) and our needs. The study attempts to bring the needs and capabilities together as shown in Figure 1.2.

FIGURE 1.2
OVERVIEW OF PLAN DEVELOPMENT PLAN



PART 2 REVIEW OF STATUS

2.1 CURRENT INTERNATIONAL INTERESTS

2.1.1 Sources:

The current thinking of the R and D community are reflected in publications and these in turn are well summarised every three years in the proceedings of the International Ship and Offshore Structures Congress (ISSC) (Reference 3) . This eminent group representing academics, research laboratories and industry review the whole area of ship structures technology in detail through some 16 committees. These cover subjects from the definition of the Environment to Dynamic Loading, from Fabrication Procedures to Design Philosophy, and include Unconventional Vehicles and Advanced Composite Materials. With some ten experts in each of the 16 committees. and typically 300 references reviewed in each of these topics, the ISSC provides an excellent source for researchers and designers alike.

In addition, review of current periodicals such as "Marine Structures", (e.g. Ref 4), and "Journal of Ship Research", as well as some of the Civil Engineering Structures volumes (e.g. Ref 5), also reveals the areas where research is progressing.

Contact was also made with leading ship structures experts internationally including Professor Douglas Faulkner of Glasgow University (Ref 6), Professor John Caldwell of Newcastle University (Ref 7), and Paul Frieze, and Donald Liu (ABS), Fred Siebold (MarAd) and LtCdr. Mike Parmelee (USCG/SSC).

The findings are discussed briefly below, and where it is believed there is a Canadian interest, this is identified in a preliminary manner and noted in "footnotes". These provide an initial comment on the possible Canadian interest only, and are by no means comprehensive. Development of an understanding of the Canadian interests in detail follows in the next section.

In this section, and throughout this report, areas of interest in ship structures are discussed under the sub-headings used in the ISSC reports. It is recognised that there are overlaps and interactions, and that items are not mutually exclusive. Nevertheless the assumed break-down is useful and recognised internationally.

2.1.2 Environment:

Collection of data on waves is of vital importance to the offshore engineering industry and the ship design community. This need is coupled with the development of models for applying the data and predicting response particularly in extreme conditions where non-linear programs are required. Measurement techniques for directional seas also require improvement.

As engineering requirements become more demanding (e.g. more rigorous design processes using reliability methods), there is a greater need for better definition of the environment. This, in the case of a ship, is a combination of the total environment and the operating envelope for the vessel. When dealing with statistical response data in extreme conditions, the modification of response due to operator actions must be accounted for. In effect, in extreme conditions it is no longer appropriate to superpose the wave statistics and the response statistics of the vessel, as in practice there would be a modification of the operation in the extreme cases. There is a need for on-board instructions and possibly monitoring systems to collect actual operationally modified data.

If a site- or route- specific wave environment is shown to be identical to that of another area in the world for which there is data, then the history of design success and the design codes for the latter may be used. If, however, there is a difference in environment from current knowledge, research work will be required. The collection of the local wave data is therefore vital.

Collection of ice environment data in a meaningful way for ship *designers* has taken a major step forward with Canada's introduction of "ice regimes", but more field data is needed to assist with prediction models, etc.

Canada is recognised as a leader in oceanographic instrumentation and measurement, and has a National responsibility to continue to collect environmental data that is relevant to its vessel operations. This includes wave statistics for the Pacific and Atlantic Oceans as well as for the Lakes, and the Arctic Ocean. (The latter is not always ice-covered). Collecting enough environmental data to assure ourselves of the applicability of design codes for other locations in the world is the minimum requirement. This element also includes the collection of ice data for which Canada has gained an International reputation.

2.1.3 Loads:

With progress in reliability analysis and more rigorous design procedures, Naval Architects are beginning to realise the need for more realistic definition of loads arising from waves or other identified elements of the environment, and for extending their analysis through to the "as-built" condition including material, fabrication, etc, properties and imperfections. Failure modes assumed have gone from a simple allowable stress approach, to include failures such as buckling (instability) and fatigue. This puts pressure on the designer to establish a clearer understanding of the loads to which his vessel will be exposed in its lifetime.

While loading from freak waves is of concern to the offshore platform designers, it is also a consideration for the ship designer. Vessel operations that require a specific heading and position to be maintained (e.g offshore rig re-supply, minehunting, towing a sonar array), can expose vessels to extreme seas without the option to select a more favourable heading.

There is continued concern about the damage caused by sloshing in ship tanks. Slamming loads and dynamic loading during icebreaking are still poorly understood. Green sea loads on the deck are also poorly understood, and can lead to damage that affects primary strength.

Increased attention to anti-pollution design and the transportation of hazardous material might lead to a more rigorous investigation of collision and grounding damage. Collision damage is a principal cause of structural failure, often leading to total loss following the initial damage.

Stochastic modelling techniques continue to be explored, and there remains work to be done in extreme value predictions, and non-linear systems.

There is a lack of data and design guidance for novel designs, and as interest in SWATH and other advanced forms (e.g. long, slender forms) increases, greater understanding of the loading is required.

The production of more rationally-based regulations for the CASPPR shows initiative in the review of codes. Since we are a country with extreme temperature fluctuations, it would be appropriate to pursue activity in this area. Canada continues to have a need for and an expertise in ice loading, and there may be a desire to investigate post - collision damage of vessels.

2.1.4 Response:

This area of detailed structural response and failure continues to attract attention, particulary as numerical methods are developed to deal with the problem. The scope of the subject embraces both global hull response and local structural responses such as buckling and post-yield behaviour of steel structures, and the progressive collapse of structural systems.

The ISSC had compared a number of commercial finite element (FE) Programs, and appeals for further contributions for comparison. A number of ideas for testing of specific ship-type structures into the ductile range are put forward to collect data for comparison and validation of numerical methods. One effort sought here is in investigation of the collapse of a system of structural components progressively rather than the analysis of component collapse, and on the tolerance of the system to damage and post-construction imperfections (such as weld induced distortion).

Long term field data is becoming more important, as the industry wrestles with the more rigorous approach, and safety factors - or ignorance margins - are reduced. Real-time monitoring is viewed by the R & D community as being a most important aspect, along with obtaining a good understanding of the significance of the data.

While vibration is considered to be a resolved issue in terms of excitation frequencies, there is a gap in the knowledge concerning amplitudes as a result of deficiencies in knowledge of ship structural damping. Noise requirements are becoming more stringent and may require additional research, particularly in the calculation of structure-borne noise paths.

Canada has interest in hull monitoring systems. The post-yield response of icebreaker stiffeners requires further understanding. Codes such as VAST could be offered for comparison with others internationally. Vibration of warships is an area of interest.

2.1.5 Fatigue and Fracture:

The international community recognises this as a major thrust now, and a great deal of effort is focused in this direction. The fact that very few, if any, ship structural failures are due to simple ductile collapse of the hull girder and many are initiated by, or progress by cracking, is an indication of the significance of this matter. However, the incidences of brittle fracture are declining as greater use is made of tougher steels. There are 272 references in the ISSC committee report in this area, as well as 58 recommendations for further work.

Two main thrusts are noted - the first is the effort to establish a fundamental understanding of the phenomenon at the microscopic or metallurgical level. The second is that the technology is being applied in real designs now.

A major concern relates to the behaviour of welded joints in fatigue and in particular in High Strength Steels (HTS) where the overall stress level is higher, but the fatigue life of the joint is not. This has an impact on through-life costs of the use of HTS. Large scale testing is advocated. Other recommendations include the establishment of a materials data base including fatigue and fracture properties, further exploration of processes that reduce the likelihood of weld metal property deterioration (e.g. narrow-gap welding for thick steels), and greater understanding of residual stress behaviour.

A concern that has manifested itself is that the use of HTS leads to reduced plate thicknesses (for equal margin against failure) and as a result, the effects of corrosion and fabrication distortion become comparatively bigger, and the ignorance of the nature of residual stresses becomes of concern.

Canada has made use of HTS in both Arctic structures and vessels and warships, and there is a possibility of its increased use in the so-called "deep water Lakers" or "80%ers". Concern about the fatigue life of joints and residual stresses such as thermal stresses would indicate that some expertise in this area must be maintained.

2.1.6 Structural Design Philosophy:

The concern in the community is to increase the transportation effectiveness of the marine sector, and as a result the economic, safety and effectiveness trade-offs for structures. There is some evidence internationally of the current cost effectiveness of re-design and conversion of existing vessels for life extension and improved performance. This presents technical challenges. It is in this area that the operations and the design and fabrication interlock, as designers strive to account for through life costs, maintainability, etc. Damage tolerance becomes a factor in these deliberations. The tendency towards risk-based design and fabrication is clear, and requires more input into quantifying quality standards for workmanship and fabrication risk.

Structural reliability methods have now reached a degree of maturity that they can be used to calibrate codes or examine individual cases and assess the safety levels against targets.

The ISSC calls for a cross-fertilisation with other engineering disciplines which have more experience in the area of reliability methods and probabilistic approach to structural design, notably the aerospace and nuclear industries.

The cost-effectiveness of conversions and modernisations may not be applicable in Canada, but prevails at present. Canada continues to explore these new design approaches for ship design, and has a resource in the form of the work performed on the CSA codes for offshore structures to draw on. These latter are currently under international scrutiny. The technique relies on the use of a full scale data base, which, in areas of interest to us such as the Arctic, is scarce.

2.1.7 Materials:

The most significant materials-related factors in recent years have been the wider acceptance and use of High quality, high strength steels (HTS). Offshore structures and Naval vessels are the leading users, but commercial vessel operators are beginning to see advantages also. The increased demands on welding control that the high alloy QT steels require have been offset somewhat by newer steels which achieve toughness and strength through other than quenching and tempering - "Thermomechanically controlled processed steels" (TMCP) and precipitation strengthened steels (e.g. HSLA 80). With their increased use comes problems with the higher working stresses, principally fatigue life of welded joints.

The increased use of composite materials is being explored at a steady but slow rate. These include not only polymer reinforced materials, but various steel composites, corrugated sections, etc. The low modulus of GRP structures has limited their use in all but small craft and special (MCM) vessels, but more advanced composites show promise for structural components.

Canada has no capacity to make low alloy high strength steels, and even imports its QT steels. There has been little interest in pursuing alternative materials, although a recent intitative by Government and Industry to explore applications of composites in the marine industry may accelerate this activity.

2.1.8 Fabrication:

The emphasis in this area is on the increased importance of fabrication quality, quantifying tolerance to defects and imperfections and considering fabrication and maintenance costs at the design stage. There is a lack of data for good cost models. Some promising new welding techniques offer solutions to reducing the size of the heat affected zone and residual stresses in welding - both of which are important in modern high stress designs.

While Canada has state of the art welding technology, it is not clear to what extent this is in the shipyards. Canada was assessed in 1980 as being at the middle level of international ship production technology. Shipyard management has suggested that education and training and yard machine capability are restricting the use of modern approaches to design of vessels.

2.1.9 Topics of Interest:

In summary, the principal topics of interest to the structures research community at present are:

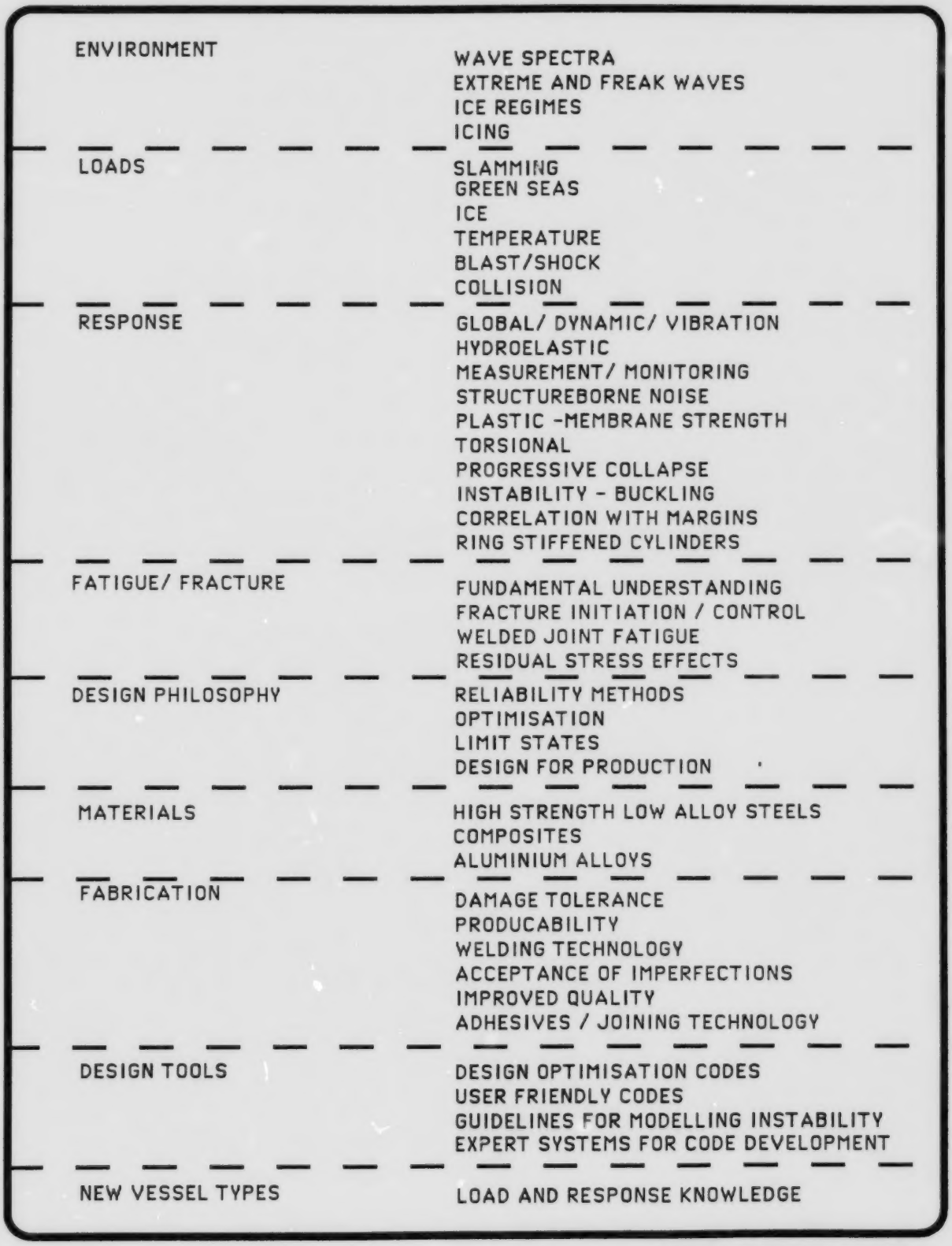
Greater understanding and definition of Environmental Loading
- Wave spectra directionality, extreme statistics
- Ice regimes
- Slamming Loads
- Temperature Loading

Loading and response of Novel/ Advanced vessel designs
Reliability methods and rational design
User friendly Design (vs Analysis) Codes
Re-assessment of design codes and safety factors
Acceptance criteria for structural deficiencies
Fatigue and fracture control
Damage Tolerance guidelines
Effect of imperfections in material and welds
Instability of structures under combined loading
Plastic collapse
Guidelines for numerical modelling of instabilities
Ring stiffened cylinders (Submarines, pipelines, offshore platforms)
Knowledge of stress concentration factors and their modelling
Measurement of responses in extreme seas.
Correlation of response measurements and margins
New materials, HSLA, Composites
Improved Fabrication Quality and its effect on design.

These are summarised in the ISSC categories in Figure 2.1.

FIGURE 2.1

INTERNATIONAL SHIP STRUCTURES ISSUES



2.2 CURRENT CANADIAN PROGRAMS

2.2.1 The Overview:

German and Milne Inc have conducted a review of recent Canadian programs for IMD (Refs 1,8,10). These documents address the current situation in a thorough manner. It is not planned to repeat this effort, and the reader is referred to the references. Where necessary the information is updated herein, while the approach taken will be to provide an assessment of the driving forces and needs which give rise to the current programs

2.2.2 Navy Interests:

The Navy has a committee (the DHRDC) that advises and co-ordinates their ship structures research activity, and to which the Transportation Development Centre and NRC/IMD are party.

DND is currently updating design standards for Canadian Warship structures. There is a long term program in place to establish an understanding of the global response of warships to extreme seas, through physical, numerical modelling and full scale data collection. A major project at the moment is that to investigate the welding of HY100 steels commenced for the submarine acquisition program. DND is also starting a major thrust to quantify fatigue performance and to improve damage tolerance in both improved resistance to crack growth and blast resilience.

DREA's major thrust has been in the development of structural analysis tools (e.g., VAST), including strength and vibration, and on slamming and sea loads. There is also significant effort on submarine hull analysis. DREA has commenced a program in probabilistic methods for warship design. DREA is also investigating fire-safe non metals, and welding., and had sponsored research in GRP superstructures where improved fatigue life is anticipated.

The DRES program focuses on shock and blast effects on structures, using numerical, experimental and full scale blast trials approaches.

DREP is focused on coatings for steels, corrosion, and fracture toughness studies of HSLA steels.

2.2.3 Universities:

Memorial University of Newfoundland (MUN)'s Ocean Engineering program continues to execute ship research geared principally towards the effect of extreme seas or ice on ships. Their program, outlined in Reference 11, is closely tied to the IMD program and facility. Their interests have been directed at offshore structures research - and in particular the impact of environmental forces. Experimental programs investigating the corrosion fatigue, fracture and non-destructive examination of large scale tubular joints are underway as part of a joint Government / Industry / University research program. A program to investigate the interaction of ships and ice has also been pursued, and the University has developed some expertise in elastic physical models of structures.

The Technical University of Nova Scotia (TUNS) has no specific ship structures research activity, (12) they being predominantly strong in the hydrodynamics area. Some work on fracture and fatigue is undertaken in the metallurgical department, and work in underwater explosions, and mathematical modelling to support eigenvalue analysis is pursued with DREA. However, of great relevance is the location under one roof of both Naval Architecture and Advanced Industrial Materials (Composites) training programs.

The University of Alberta's ship structures related programs are those executed at C-FER. This is limited at the moment to work on corrosion of welds in the Arctic and to a study for a commercial client of the optimum structural design for an icebreaking vessel. C-FER is establishing a unique testing facility, but is likely to be focused on pipelines, drilling and exploration work, and corrosion.

The University of British Columbia (UBC) has an on-going program in ship vibration funded by the Defence Department (DREA), specifically addressing methods for assessing the effect of structural modifications on the dynamic response of the ship structure. This program has been running for five years, and is now tackling the inverse problem of providing tools and methods by which a designer can make the "best" structural changes to meet specified target levels of vibration (13). This work is considered to be of international calibre, and in line with work being pursued at the University of Michigan.

UBC is also pursuing the problem of ship collision and grounding, and the ultimate strength of the hull. The work uses an analytical approach to examining the dynamic effects and their influence on the total hull girder. The work is currently sponsored by US industry interests. The same establishment is working in the area of structural response to air blast for DRES, and also has a reputation in the area of wave- and current-induced forces and loads on offshore structures.

Ottawa University has a graduate student working in the hydroelastic response of ships while icebreaking. The project is a direct spin-off from CCG funded work at Fleet Technology, and is partially funded by Fleet, NSERC and TDC.

RMC performs structures research for the Department of Defence. They are working in HSLA steels, fracture mechanics of thick plate, lattice mast structures, and on connections and structural optimisation. Other Universities undertake structures-related work and have facilities of value to marine structures research, but no current directly relevant programs.

C-FER, which is attached to the University of Alberta, has done work in weld corrosion for Arctic vessels, and has a current experimental and analytical program for a major resource company in the optimisation of ship bow structure for icebreakers.

C-CORE, which is attached to MUN, studies ice properties from a geotechnical and forecasting viewpoint, which work is related to ship navigation safety, but has no ship structures program at present.

2.2.4 National Research Council/Institute for Marine Dynamics:

While NRC has a responsibility for research in support of transportation, there has been little direct involvement in ship structures. Instead NRC has focused on hydrodynamics and ice forces. IMD has no ship structures research program *per se*, although its work in ship-ice interaction dynamics is bringing it into contact with work in the area of dynamic response of ship structures. In addition there is some interest in the response of vessels in extreme seas and the modelling of this (both physical and analytical).

2.2.5 Government Departments:

Transport Canada, through Coast Guard and the Transportation Development Centre, has sponsored much of Canada's structures research. As regulators, and as operators of a major fleet of ships, the Canadian Coast Guard has a dual interest in ship research and technology. Coast Guard Northern has been that major funding source for research into ship structures over the last ten years, culminating in the proposals for revision of the Canadian Arctic Shipping Pollution Prevention Regulations (14). This work has been executed by various industry, University and Government organisations, and has produced not only a far-reaching and logically based set of regulations, but in the process has produced structures expertise and research findings that have gained international recognition.

This aspect of the work on the CASPPR is expected to continue at a reduced level, in order to refine aspects of the regulations, and maintain an expertise that will be available for subsequent updates as experience is gained. The work continues at present with investigation of steels, temperature effects, and review of the new formulations for design of ice strengthened vessels.

In other regulatory areas, the Ship Safety Branch identified the already-discussed "80%ers" as an area for concern as well as the effect of the IMO regulations. In addition, in the future, they saw the possible need to investigate the effect on Ro Ro ferries of the possible introduction of regulations to allow downflooding of vehicle decks, with possible changes to configurations and design deck loads.

As operators, Fleet Systems' concerns are confined to investigation of specific structural failures - notably ice damage. There is some interest in the future in "optimising" hull structure - to reduce hull weight and deadweight in ships requiring high payload (e.g. NAVAIDS tenders), and there is some concern that rules that require pollutants to be carried away from the ship's side will also require some investigation in the future.

There is also a possibility that the introduction of fast SAR cutters and vessels for interceding (drugs, etc) will require more careful attention to lightweight (warship) type structures, and the effect of slamming, etc.

The Transportation Development Centre (TDC) has sponsored much of Canada's ship structures research outside the Defence department - much of it for vessels in cold or ice-covered waters. TDC has suffered from several changes in focus and budgets which have seen its mandate broaden to include R &D for the Canadian Industry as a whole, and shrink to a specific mandate in support of CCG operations. Much of the work in the past has arisen from Unsolicited Proposals, and "opportunity programs" such as those for full scale testing of ships. It is part of the purpose of this study to generate a program outline for TDC to bound and focus its activity without ignoring the significant needs of its diverse clientele.

The Department of Fisheries and Oceans (DFO) has no direct sponsorship of ship structures research at present but does carry out work in support of its operating fleet.

The CANMET division of the Department of Energy Mines and Resources is performing work on materials and welding, including the welding of high strength steels, and corrosion of welds in the marine environment. In the development of a ship structures program, the role of CANMET will be a strong one on the materials issues.

The Department of Public Works (DPW) has programs investigating ice strength and forces on fixed (civil) structures, and has been concerned about the behaviour of structures under tow and set-down in the Arctic.

2.2.6 Industry:

Industry is represented by two groups - those who need and sponsor research, and those who execute it. It is assumed that the latter have current programs which are covered by all the sponsors, and so these are not discussed here, but rather in the capabilities section. Industry *sponsors* are discussed.

Canadian Shipowners'Association: The CSA represents Canadian Shipowners - principally those operating on the lakes. One area of structural research that is of interest to those operating ships in the Great Lakes and Seaway is that of the "so-called 80%ers" . As shipping companies seek greater utilisation of vessels plying the Seaway, they have constructed vessels that have been classed to permit them to sail outside the Seaway, notably to the Caribbean.

Environmental data for the "Gulf corridor" is being collected, and attempts have been made to collect stress data on these vessels, but the data base is building very slowly. It may be assumed that shipping companies will continue to explore the opportunities to operate these restricted dimension vessels in areas beyond those for which they were designed, and that studies on the implications of this will be made. Of particular concern with this topic is the potential for the use of High Strength Steels to meet Class requirements, and the potential for subsequent fatigue problems in vessels that are known for their cyclic "springing" response.

The introduction of proposed IMO regulations for damaged stability and subdivision has also provoked some investigation of the ability of self-unloaders (Lakers) to meet these proposed regulations. In addition to concerns about structural subdivision and integrity, there have been investigations into the effectiveness of the double hull configurations against collision damage.

Oil Exploration/ Production Companies Gulf Canada has established a significant data base of ice and wave loads on structures and vessels, and many years of full scale data. Some of this is proprietary, but the company has demonstrated a willingness to sponsor practical research in structures to complement its efforts in frontier drilling. Esso continues to work in ice forces on structures and has recently upgraded its outdoor ice testing facility in Calgary. AMOCO (formerly DOME) has been a leader in ship design for the Arctic, has exported much of this technology, and is currently sponsoring projects on ice forces, and on the optimum design of a large icebreaker bow structure (at C-FER).

Others: National Sea Products has participated in and co-sponsored work on ice loading on fishing vessels resulting from concern about ice damage to vessels seeking the Northern Cod stocks, but that industry has fallen on hard times and has no other programs going.Neither BC Ferries nor CN Marine have current programs of structures research.

Classification Societies: The major International Ship Classification Societies make major contributions to ship structures research world-wide but maintain relatively small operating offices (surveys, etc) in Canada. Det Norske Veritas (DnV), the Norwegian-based Classification Society, is the exception, and at one time had a strong consulting group in Canada. DnV did participate in the CASPPR update and were particularly concerned with fracture and probability methods.

2.2.7 Level of Current Programs:

It has not been possible to establish a reliable figure for the current level of funding of ship structures research in Canada, due to overlaps both in funding sources and in technical aspects. In addition the amount has taken a sudden drop as the work on CASPPR has wound down. However, based on informal comments from sponsors and the author's opinion, it is estimated that Canada spends some $6 - 8m on ship structures and materials research per annum.

2.3 CANADIAN CAPABILITIES

2.3.1 General:

In this section, a review of the capabilities and resources that are available in Canada is made. This review is based on discussion with principal participating groups and the author's own observations over 20 years. Not all commercial participants are mentioned, as the objective is not to give a catalogue of resources so much as an indication of strengths and weaknesses. Those organisations who feel that they have been wrongfully omitted should accept the author's regrets in advance, and notify him for inclusion in later revisions.

The Structures Research capability has been reviewed under three headings representing the three "fronts" of research - **full scale data collection, experimental work , and analytical work.**

It is noteworthy at this stage that Faulkner in (4) discusses the progress of structures research in two distinct (and non- communicating) activities -

> "(i) theoretical and highly-tuned research based on engineering science principles directed at specific theoretical problems, and
> (ii) design and technology development marked with breadth and versatility, but often with little attention paid to the rigour of the analysis".

His appeal is for the two to cross the boundary, to allow designers to use the powerful tools that are available. This must also be an objective of this work.

2.3.2 Full Scale "Test Beds":

For ship structures research, the vessels in the "National Inventory" are all potential full scale test beds. With a relatively small merchant marine, Navy and Government fleet, and a lower than average commitment to R & D spending, it might seem that Canada would be poorly positioned to contribute to the full scale data base so essential for ship structures development. In practice however, Canada has shown significant initiatives in this area for years - an early example being the work by Mathews (15) on the springing response of Lakers. More recently through a series of full scale trials of ships in ice by various parties, Canada has established a recognised position of authority in the instrumentation of vessels for structural response measurements.

Canada possesses an ideal vessel in which to study commercial ship structural response in the form of **MV Arctic**. It is operated as a commercial vessel, but there is also a mandate to carry out research. This latter situation has resulted in the vessel being outfitted with an extensive data acquisition system (on two occasions) which is generally under-utilised.The vessel is also somewhat unique in that it is an ocean-going vessel yet, being designed for the Lakes it has principal dimensions that are somewhat unusual, and, being a heavy icebreaker, a bow design and structure that is different. While these features may seem to detract from its usefulness as a general research platform for merchant vessels, it still represents a most valuable opportunity for structures research at sea, and therefore a significant asset.

Icebreakers in the Canadian commercial and Government Fleets have been and are available as full scale test beds. Their structure is only suitable for research in structures with icebreaker-type scantlings. However, their current and future utilisation is such that their availability is likely to be higher than some other vessels. Many have adequate space on board for scientific personnel and equipment. A deliberate effort to plan and allocate time for trials on these vessels is needed.

Canadian Navy Vessels have been used for Navy-specific structures research. This has included global hull response measurements due to waves and blast as well as local structural response measurements such as flare slamming. The number and age of Canada's Navy vessels is such that ship availability has been a problem. The arrival of a new batch of frigates should provide an opportunity to release older vessels for research purposes, although the value of doing so on older hulls may be questioned.Some structural research has been performed on the Navy's dedicated research vessels, although higher priority is usually assigned to other areas of research for which the vessels are purpose built.

The Department of Fisheries and Oceans also has a fleet of research as well as patrol vessels on which research could be performed, the latter having suitable accommodations and facilities.

DFO has recently chartered a 75 ton SWATH (Small Waterplane Area Twin Hull) vessel for evaluation in the Hydrographic and Patrol roles.DREA and IMD are participating in trials. The vessel is built in aluminum, and is clearly of interest both specifically and for future possible advanced vehicle technology applications. While this indicates an encouraging move initiated by DFO to examine advanced vehicles' performance, little is known about the program, and it has not become a National effort.

Fishing vessels, tug/barge combinations and lakers have been used in the past for specific projects, but availability has often been a problem, and accommodations and operations are not conducive to research. The design of these vessels does not lend itself to investigation of more general ship structural problems. With the current attention on "Ocean going lakers", and the number of vessels not in service due to reduced activity in grain and ore on the Lakes, there would appear to be opportunities for ship-specific, dedicated, full scale testing on these vessels, through negotiation with the operators. Canada has a substantial RO-RO ferry fleet, but there has been little interest in structural aspects of ferries. The residue of available commercial vessels in Canada is small.

Various proposals have been discussed over the years for a dedicated research vessel for Canada, the latest being promoted by Memorial University and the IMD. While this could be an excellent opportunity to design and build a full scale structural test ship from "scratch", the cost will be substantial. It could incorporate features such as alternative structural arrangements port and starboard, built-in pressure panels, intelligent structures, etc. However, this should not be pursued until the focus of the research program is established.

Full scale testing involves onboard instrumentation, and it is in this area that Canada has made an international impact. The perception of others in the field (for example reference (16)) is that we are among the leaders in this area. Companies involved in shipboard instrumentation include AMOCO (Canmar), GULF, German and Milne Inc (NAWS), Weir Jones, SEIMAC, METRICOMP, MARTEC, and Fleet Technology - a significant capability in relation to the national structures effort. In addition most of the Defence laboratories (including NETE) and IMD have undertaken shipboard instrumentation projects.

Finally it is worth emphasising the Environmental conditions around Canada in relation to the collection of full scale ship response data. Canada's oceans and lakes provide an exceptionally wide variation of sea environments close at hand.Canada's ship testing area encompasses conditions from ice-covered waters and icebergs to Winter North Atlantic conditions as well as short-fetch conditions and shallow water environments. The proximity of this range of environments is reasonably unique, and surely must be part of Canada's strategy in participating in International research.

It is concluded then that Canada has, in the **MV ARCTIC** a world-class ship structural research vessel whose availability and suitability are good. Other specialist vessels are available for more ship-type specific research , the most available being icebreakers, and possibly Government research vessels, with commercial vessels being generally less suitable and available. Lakers and Ro-Ro ferries may be of particular interest Canada has been able to take opportunities for full scale data collection. This has resulted in the Canadian industry establishing a considerable capability and reputation, particularly in instrumentation for measuring structural response. In addition, Canada's marine environment offers a wide range of effects around its coast and within its boundaries. Proposals to build a National Research Vessel have been considered, but funding is not likely at this present time, nor should the project commence without a clear program focus.

2.3.3 Experimental Facilities:

A report was recently prepared by Professor J. S. Ellis of the Royal Military College, Kingston for the Department of National Defence, in which he reviewed "Canadian Facilities for Ships' Structural Testing" (ref 2), (March 1989). The report lists 83 organisations in Canada that have structural testing (including Metallurgical testing) facilities of some kind, tabulating these with basic data. More detailed information received from each organisation is filed with DND (DMEM).

The survey was made by questionnaire, which has been included in this report as Appendix B. The report did not include the details of, for example test machines, nor did it express any opinions. This report is a valuable source of contacts, and provides an overview of facilities across Canada - not restricted to 'traditional' marine research establishments. As might be expected, many of the laboratories were in the civil engineering area.

This author - along with experienced colleagues - reviewed the report in order to assess the quality of the facilities available. It would appear from this review that Canada lags a long way behind Europe, Russia, Japan and the USA in terms of testing capabilities. Of course, the detailed descriptions that are held by DND may provide more factual data on such items as testing machine capacity, etc. At the time of the report, large scale, versatile facilities were completely lacking. Since then, the new laboratories at C- FER have been started. This will include large test frames and cold chambers - suitable for large scale testing of steel structures. In addition some organisations are acquiring more capable fatigue machines.

It is the conclusion therefore that Canada does not appear to have any particularly unique experimental / laboratory capability and is lacking specifically in large scale fatigue or static testing resources (except perhaps for the C- FER facility). Most facilities appear to be routine "university" type facilities.

2.3.4 Numerical /Analytical Capability:

In assessing the analytical capabilities in the country, it is best to divide those into the areas of fundamental research, and analytical support for design. In the former category there are few real efforts in Canada, while in the latter category universities, Government labs and industry are making useful contributions.

Most universities have good analytical capability in structures in their Civil Engineering Departments. Of those that have Naval Architecture programs or Shipbuilding Engineering programs, UBC has the most ship structures related activity, and TUNS the least. C-FER, although an experimental facility primarily and making no claim to fame in analytical techniques, supports experimental programs with non-linear FE modelling - ADINA being a favoured code. MUN has programs in support of the offshore but did not provide details.

Many of the ship designers and research groups have structural analysis capability which spans from a reasonable capability to use FE codes in design situations, to advanced structural techniques such as reliability methods, limit states design, etc. Fleet Technology Limited has assembled a unique team that blends materials, fracture, reliability and ship structures expertise to tackle ship structures research in a "systems" approach. Amoco (Formerly Dome-Canmar) has a strong but diminishing group involved in icebreaker structure development. Other strength in ship structures design - and therefore to some extent in development - exists at MIL Systems Engineering, German and Milne, Robert Allen, St John Marine Consultants and RDS/Donelad.

In code development, Martec Ltd in conjunction with DREA has the Canadian expertise, having developed the codes of the VAST series, under contract to the Defence Department. These codes incorporate special elements (e.g. propeller blade root elements) and good Pre-and post-processing packages as well as common data bases. They have been acquired by the Netherlands Navy but are not in wide-spread use, and according to a Martec spokesman, have not met with commercial success yet. They are linear only and in the face of more powerful non-linear codes will require upgrade (a geometric non-linearity is planned) to become more widely used. The experience of this development has however made the company a powerful resource in Canada. Other FE code development takes place at H. G. Engineering (FESDEC), Carleton University (ASGARD) and in a number of Universities (e.g. Mc Gill). Few codes are developed to commercial standards or become commercial successes, and many duplicate available codes. Canada thus has reasonable strength in Structures modelling.

2.3.5 Research Management:

The management of quality research is also a desirable capability if there is to be a meaningful research program. The selection, and quality of the research as well as the content and applications are all part of the research program, and can greatly affect the progress of the technology and the ability to obtain funding. Defence laboratories execute and manage research both in-house and with contractors. The Transportation Development Centre manages some $25m worth of research per annum, of which about $5m is in the marine mode and perhaps under $1m in ship structures. During the development of the CASPP Regulations for icebreakers, Coast Guard managed some $15m worth of the total estimated $20m spent.

The Department of Energy Mines and Resources has also managed large scale multi-participant research programs at Universities and in industry in the area of materials and welding research. Universities manage their own research, and recently a few contractors, have been contracted to manage multi-participant technology-intense research projects on behalf of the Government or major industries.

The management of ship structures research requires a sound understanding of the subject matter including the International state-of-the-art and the capabilities and the limitations of those executing it, in order to ensure that wasteful repetition does not take place, that the research content is of high quality, and that the research is meaningful in the overall context of the science. The need to support International congresses such as ISSC to maintain this knowledge base for this reason was well stated in Reference 10. Communication among the interested parties is essential.

The success of research management should, of course, be measured by the resulting increase in knowledge and / or capability. However, the research manager's function embraces much more than simply the management of specific programs of research. It starts with needs development, planning and funding approval, and it ends with quality assurance, information application, etc. In light of the ever-reducing commitment by politicians to research in Canada, and to the marine area in particular, it must be concluded that the marine fraternity has failed to "sell" the importance of marine research in this country to the politicians. Canadian research managers are either perceived not to be delivering useful and appropriate results, or they have failed to make a strong case for the research. Therefore we must conclude that in this capability we are weak.

2.3.6 Overseas Perception:

In the course of this and other work, the author has discussed the overseas perception of Canada in the ship structures research area. While this is only one perception of that aspect, it is relevant, and is based on discussions with leading overseas structures experts.

In general overseas experts are unaware of Canada as a contributor on the ship structures front in general. This perhaps manifests itself in the reluctance that the US and UK have to share data through the military exchange groups.

There are two notable exceptions. The first is, of course, our world reputation in icebreaker research. This is recognised, and acknowledged everywhere, and could continue to be a marketable capability. It is currently supporting efforts of Canadian companies in Russia, the USA, Finland, Norway and recently Sweden. We are acknowledged leaders in the loading of ship structures by ice.

The second area is that of hull monitoring and structural response and load measurement. As stated earlier there is good capability and there have been some very ambitious programs in both ice loading and slamming. There is scope here for a continued thrust, as "feedback" and monitoring are growing in importance.

The Canadian contribution over the years to blast research at DRES is well recognised, although one interviewee noted that we were once again the suppliers of the environment and facilities and were not doing enough original design for testing.

On the negative side, we are perceived as having no focus, and frequently repeating what others do or have done.

2.4 SUMMARY OF STATUS

Programs in ship structures research are being pursued across the country. The biggest contribution to the field has been from the Navy, followed by the Coast Guard in its commitment to upgrade and revise the Arctic ship regulations. This latter activity is diminishing, but has left a community that has expertise and in many cases a solid understanding of the practical problems of ship structural response. In practice the technology that has been learned has been embodied in the modifications to the MV Arctic, the Swedish icebreaker "ODEN", and in the development of the Polar 8 icebreaker design.

Canada's strengths appear to be in full scale testing and measurement, with modest support from at least one centre in which the development of FE modelling tools can take place. Experimental facilities are not world-class.

The ability to manage research in this area, if measured by the success of the programs, is adequate, but if based on the success in persuading politicians to allocate funds, may be said to be weak.

PART 3 THE NEED FOR SHIP STRUCTURES RESEARCH

3.1 THE MOTIVATORS

3.1.1 Introduction:

The needs of the marine community world-wide to continue technology development in ship structures should be driven by one, or a combination of the following:

a) Improved Ship Safety
b) Reduction in Pollution Risk
c) Improved Reliability
d) Reduced capital cost
e) Reduced in-service maintenance - therefore cost
f) Improved vessel performance
g) New vessel configurations
h) New vessel operations
i) Application of new materials/ fabrication techniques
j) Becoming informed to support buying and operation

In most cases,the needs (or market) should drive development not the technology, and it is the identification of these needs that is the subject of this section.

It is recognised that not all research should be geared towards identifiable short or medium term problems. Some activity must be allowed to explore technologies that *may* have applications downstream, but for which applications are not well defined until the technology is developed further. However, in a shrinking budgetary environment, such R & D must take second place to that which is geared towards perceived needs. It is also observed that short-term research is usually driven by the need to solve a problem or obtain a competitive edge. It will therefore generally be of value to and funded by one particular user or user group, and is of little interest in the development of a National program. We are mostly concerned herein with medium and longer-term needs.

3.1.2 Safety, Pollution Prevention and Reliability:

Vessels continue to be lost at sea. The figures are in fact quite staggering. In recent years the figures of vessel losses have risen significantly because of the fact that at least two major military conflicts involved the sea and shipping -- the Falklands War and the Iran-Iraq war. Nevertheless the losses due to non-military events are still large. Some statistics of interest, taken from References (3) and (17) are highlighted below:

Between 1976 and 1986,

(i) 8.5% of all casualties were from a cause related to structural design, fabrication, etc.
(ii) 42% of these structures-related casualties were total losses
(iii) Average hull damage frequency is 2.55 per 1000 ship years.
(iv) Between September 1980 and September 1988, more than 60 bulk and ore carriers were reported as total losses - *one every two months*.
(v) Most of the structural casualties occur in vessels between 10 and 25 years old.

While it is still clear that human error and collision account for the majority of non-military casualties, there is still sufficient evidence that failure in design and construction contribute to ship loss and therefore life loss and pollution. This is particularly so for general, bulk , ore and combination vessels. In effect, for whatever reason, be it operation in extreme environments, deterioration of the structure. lack of building and maintenance quality, or simply lack of knowledge to design for all conditions, there is room for improvement in the structural design of existing vessels.

It is also clear that, since few, if any, of the failures were due to ductile failure of the main hull girder, the traditional design approach which is based on that failure mode, is inadequate.

In this era of increased awareness of environmental issues, the transportation of pollutants and hazardous goods by sea becomes of concern. It is clear that relatively minor structural imperfections, such as small cracks, which allow the escape of pollutants, are not acceptable, even if there is no immediate risk of large-scale ship failure.

While collision damage can hardly be described as a design- instigated failure, post-collision damage should possibly be a consideration to designers. The progressive failure of structure such that a medium scale collision that is not at the outset catastrophic becomes so, is a phenomenon that could be addressed in the design - and to some extent - is in combatant vessels.

3.1.3 Reduced Costs:

Owners and operators of commercial vessels and (to a lesser extent) Government vessels, are interested in initial and operating costs.

However,their perception is that, particularly for outfit-intensive vessels like ferries, etc, the steel work is not a big cost item and there is little to be gained by making improvements. In fact it is becoming more obvious that the use of High Tensile Steels (HTS), leading to thinner plates and higher overall stress levels, may lead to *increased* costs associated with the prevention of distortion, welding, crack repair and coatings as corrosion allowances drop. It is important that through-life costs be considered in the design of structures. Savings in repair hours and down-time can be affected if detailed design, maintenance and coatings are properly attended to. This is an education process, and the trade-offs and the role of Quality Assurance, are not well established. It requires a new approach to the design and build process.

Reduced cost potential has not in the past been considered to be a major motivator of research in ship structures - largely due to the ignorance of the potential savings to be made in well designed and constructed vessels. Of particular concern to this researcher is the attitude of one potential user group - the shipyards - who survive on repair work, and who have, it seems, mixed feelings about improved structural reliability and reduced maintenance costs. Attitudes are changing however, and the Navy now considers that a large portion of its structures work is targeted towards reduced through-life costs.

3.1.4 Improved Performance/ New Operations:

This criteria motivates much of the research that has been pursued in Canada recently - be it for icebreakers or warships. Research by the CCG designed to upgrade the CASPPR was as much to extend operations as it was to ensure safety in the higher classes of Arctic ships.

The work on the so-called "80% ers" so that vessels designed for the Lakes could transit the coast to the Gulf of Mexico, was addressing a new operational need. Marine Atlantic sees potential for year-round shipping in the sub arctic shipping control zones, which would lead to the design of vessels with some icebreaking capability but no compromise in fuel efficiency in open water.

Much of the Navy research into structures is driven by improvement in performance of the structure with respect to better ballistic protection - which for a warship is improved performance in its combatant role.

3.1.5 New Vessel Configurations:

For the country that pioneered the hydrofoil with its Maraging steel foil, it is not surprising that some work continues in the area of advanced ship concepts. Here the research field is wide open. New configurations of vessels - catamarans, SWATH, SES, ACV, and Hydrofoils as well as innovative offshore designs require fundamental investigations into design loads and responses. Internationally there is still a perception that more competitive sea transportation systems will continue to be developed -higher payload at higher speed for less cost. Many of the most promising advanced vehicle concepts offer this - and in particular maintenance of speed in a seaway.These advanced concepts require reduced structural weight. In the case of the most promising, SWATH (Small Waterplane Area, Twin Hull), the proportion of vessel that is "hull" is larger than for conventional vessels, and there is a need to reduce the hull weight density. At the same time the structure is subjected to some loads not normally experienced in a conventional vessel. Clearly this is an avenue in which research is needed if there is a demonstrated requirement for the vessel type. Current interest in this vessel is being seen in Canada with a DFO initiative.

3.1.6 New Materials/ Fabrication Processes

The introduction of new materials to ship structures is also likely to be motivated by a combination of the foregoing factors. The marine industry being a small user of steel in Canada relative to other industries (construction, autos), is required to adapt to available domestic steels, or to buy from abroad, as has happened with much of the Beaufort Sea activity. Designers must take cognisance of the performance and availability of steels, and their "fabricability" in the domestic industry.

As the design processes become more rigorous and previously used "safety factors" diminish as probabilistic methods and limit state design approaches are adopted, knowledge of material properties in the post-fabrication condition become more important. Quality of fabrication, and attention to such details as weld alignment, distortion and its correction, and proper handling, storing and heat treatment of material becomes more significant. This creates a burden on existing yards who may be required to re-invest in training, capital equipment, etc.

New materials such as composites, pose an even greater challenge by virtue of the fact that the designer can create the material to have the desired properties, as well as, and in parallel to, the design of the component or structure. Composites can be constructed with preferred orientations of strength properties, and can lead to tremendous weight savings, as well as providing special properties, such as acoustic transparency, low reflectivity, flame retardation, etc.

The need for structures research to take advantage of new materials for commercial or other reasons is therefore present in Canada as elsewhere. There is an indigenous "materials" industry that will influence design and fabrication, and there are the special environmental requirements of operating around Canada's coastline.

3.1.7 Becoming Informed:

Occasionally a reason for carrying out research is given as needing to become an "informed buyer or operator". This is particularly heard in Naval circles. One reason given for this is that some of the required information is sensitive or classified (e.g. submarine hull collapse data) and NATO allies are reluctant to pass it on. If Canada is buying a foreign "product" from a foreign commercial organisation without the full commitment of the foreign Government throughout the life of the product , the buyer must carry out enough work to support the product in Canada. In addition, "being informed" is necessary to determine the impact of changes in operational use in the Canadian environment.

Where there are published sources, such "education" can be achieved through the detailed scrutiny of other's research, and by participation in international bodies where information flows. Having some useful and significant contribution to make at these occasions is perhaps the surest way to receive knowledge, and to be able to distinguish between the real and the plausible.

The need to become informed as operators and buyers is recognized, however it is often not true research, and it should rarely provide an excuse for repeating research performed elsewhere. The budget assigned to this type of effort should be a small portion of the total R & D budget.

3.1.8 Summary:

The above provides an overview of the factors driving vessel structures research in a general sense. These are not specific to Canada although we have, in the above, provided examples of interest to Canada. Clearly these motivational factors are of significance to Canada. Canada has enough of a marine activity domestically with specific Canadian constraints or requirements, that it cannot "opt out" of ship structures research.

In the next section we will explore these Canadian needs more closely, from the end-user's viewpoint.

3.2 CANADA'S NEEDS

3.2.1 Introduction:

The marine industry world-wide is not one to sponsor research. Unlike the Aerospace industry, the marine industry is mature, and there will only be small advances to be made by technology advancement, with long term returns. There are other factors such as the low profitability and highly competitive nature of the industry, and perhaps even an attitude born of years of Government support. Whatever the reason, at the outset it is important to recognize these facts. The Canadian industry is not necessarily better or worse than any other - and certainly little different from that in the USA. Therefore, we must *not* expect to measure the needs of the Canadian industry by the amount of money or commitment to Research and Development. Comparison with the Aerospace industry, for example, is neither appropriate nor useful.

The Offshore industry on the other hand is, at certain times, a resourceful and profitable industry, and has driven much of the research that is related to ship structures. This is true in Canada and the US as elsewhere, where the major industry sponsors of marine related research have been the oil companies with their interest in the exploration and development of frontier offshore resources.

The Government is an operator of several major fleets and therefore it is appropriate that it drive and fund much of the marine research, particularly since Government fleets are operated on a different basis from commercial fleets. In addition, in this country as in others the Government plays a hand in subsidising the marine industry - or the shipbuilding industry - in one form or another. This subsidy is always up for review of course (see for example References 18 and 19) - but it exists. One form of less obvious subsidy for the industry is the sponsorship of research that will make the industry more competitive in the world market. Examples of this exist in the area of icebreaker design, and arctic transportation and safety systems.

The needs of each category of participant (owner / operator, designer, etc) are examined and the most likely driving forces behind research requirements established, using the motivation specified previously. The results, albeit subjective, are shown in Table 3.1.

TABLE 3.1 MOTIVATION MATRIX

MOTIVATION	THE USERS										
	OPERATORS								REGS	BLDRS	DESIG
	CCG	NAVY	DFO	CSA	FVF	CFOA	CANA	BSO	CCG	CMIA	NERS
SAFETY/RELIABLITY	M	H	H	M	M	H	H	H	H	L	M
REDUCED COSTS	L	H	M	H	M	M	M	M	L	H	H
IMPROVED PERFORMANCE	M	M	L	L	M	M	M	M	L	L	H
NEW OPERATIONS	H	M	L	H	L	L	H	M	H	L	L
NEW VESSEL TYPES	L	L	H	L	L	L	H	H	H	L	H
NEW MATERIALS	M	M	H	L	L	L	L	M	H	M	M
INFORMED BUYER	L	H	L	L	L	L	L	L	L	L	M

KEY TO ABBREVIATIONS:

CCG	Canadian Coast Guard
DFO	The Department of Fisheries and Oceans
CSA	The Canadian Shiponwers Association - representing the commercial merchant fleet.
FVF	The commercial fishing vessel fleet
CFOA	The Canadian Ferry operators Association representing all ferry operators.
CANAR	The special case of Canartic Shipping and the MV Arctic
BSO	The Beaufort Sea Operations fleet. (and East Coast Offshore operations).
CMIA	The Candian Marine Industries Association - representing the shipbuilders and ship repair yards.

3.2.2 The Canadian "Fleets":

Canada has three major "Fleets" and several smaller, but significant fleets. The Navy, the Coast Guard, and the Fisheries and Oceans Vessels represent the three biggest "Fleets" - where biggest is both numbers of vessels and extent of supporting infrastructure. These three fleets could also be classified in four vessel types as: Icebreakers; Patrol, SAR, warships and Policing Vessels; Marine support (e.g.NAVAIDS) vessels; and Research Vessels. It is significant that these are all Government fleets

On the commercial side, the fleets comprise:

The Lakers, The Fishing Fleet, the Ferries, the Tug/Barge combinations. Offshore Supply Vessels (OSVs) and the general merchant fleet. This latter comprises general cargo, product carriers, container vessels, etc, is small compared to other countries and has no special requirements except for possibly ice strengthening. The one exception is, of course, the MV ARCTIC.

The elements of this total fleet that are unique or at least special to Canada and a few other countries are:

The Icebreakers
The Lakers
The Tug/Barge combinations, and ....
The MV ARCTIC

Many other maritime nations have more significant fishing, research, warship, ferry, and general cargo fleets. While we must not ignore these vessel types, we can assume that there will be information to be learned from other countries on these. It is in the four *unique* elements of the fleet that we must expect to devote the majority of our effort, and to solve our own problems.

3.2.3 The Operators:

The CSA represents owners on the Seaway and Lakes. It has a small budget for investigating common problems and is able to address problems arising from changes to regulations, etc. In addition to responding to proposed changes to regulations, this group is interested in maximising the utilisation of its fleet by new deep water operations during the closed season on the Seaway, and the current reduced requirements on the Lakes. In addition to the "Lakers" CSA also represents most of the"Deep Water" shipping companies in Canada. A major shipping event in Canada is the Northern Sealift - the annual resupply of Northern communities through the contracting of vessels by Transport Canada.

Ferry operators are dominated by Marine Atlantic on the East Coast with some 13 vessels, and BC Ferries on the West Coast, although the Ontario Government and other provinces manage ferry operations. The group are represented by the Canadian Ferry Operators Association. Higher passenger capacity and faster turn around times as well as vessel replacement programs create R & D needs in these groups, as they seek to modernise ("jumbo-ise") vessels or explore new vessel types.

In the Beaufort Sea, and the North, Arctic Transportation Limited (ATL) and Northern Transportation Company Limited (NTCL) operate a range of vessels (tugs , supply vessels) , as do the marine divisions of oil companies such as Gulf and AMOCO, who operate the most advanced icebreaker/offshore supply and anchor handling vessels. On the east Coast, a number of Offshore Supply Vessels are operated in support of offshore drilling. The interests here are in improved performance in often extreme environmental conditions, extension of seasonal operations, etc.

Coast Guard as an operator has a wide variety of vessels from small search and rescue (SAR) cutters and "lifeboats", through "NAVAIDS" vessels, to powerful ice management and icebreaking ships. Improved performance and reduced operating costs should be of importance to them, in new operations and extended seasons. They are interested in improved icebreaker performance.

DFO operates patrol vessels (the so-called "grey" fleet) and research vessels ("white" fleet) - over 250 in all, including small launches. The former are for fisheries protection and patrol and should have good, fast seakindliness in all weather conditions. The latter include hydrographic and oceanographic research vessels as well as fishing research vessels. Improved speed and seakindliness, as well as increased productivity from hydrographic vessels is of concern to them.

The RCMP also operates a small fleet of vessels.

The Navy in Canada has a small, but sophisticated fleet of frigates and destroyer types, predominantly configured for anti-submarine operations in support of NATO commitments. These vessels are in the 3,000 to 5,000 ton range and have many features in common with other Western and Warsaw pact vessels of the same size. In addition, the Navy operates research vessels, special purpose auxiliary vessels, fast logistic or replenishment vessels, and three ageing submarines which were bought from the UK. A new batch of Frigates is coming into service, and it is likely that a batch of vessels for the Naval Reserve with patrol and possibly minecountermeasures capability will also be acquired.

The Navy's need for Structures R and D at least in the short/medium term is driven by the requirement to support vessels which have exceeded their design life. This is the case for the older destroyers and submarines, and in the latter case is exacerbated by the fact that the country of origin - UK - is no longer operating and supporting similar vessels. In addition, the possibility of "offshore" purchases drives research to ensure that they are informed as buyers. The Navy is also concerned with the use of HTS (High Tensile Steels) in the newer frigates, and is focusing on reduced costs of construction and maintenance as well as improved ballistic protection.

While Tug/Barge operations were identified earlier as a unique Canadian fleet, there has been little need for technology development in structures for this group. There was concern some years ago about barge strength and distortion during log unloading for specific self-unloading barges, but no current problems have been identified.

Finally there is Canartic Shipping LImited - a peculiar marriage of shipping companies and Government - operating the unique M.V. ARCTIC. This vessel has been used extensively for ship structures research and it is hoped will continue to be so used. It has been outfitted with instrumentation, modified structurally to meet new operational requirements, and undertakes dedicated and opportunity trials. It is a unique National facility with great potential.

3.2.4 The Designers

Canada's marine industry has seen ship designers exist separately from shipbuilders. For historical reasons the shipyards did not maintain "engineering design" groups, but rather design draftspersons who produced working drawings from other people's designs. The independent designers protected their independence and right to"shop around" for the "best" Yard. This approach has some disadvantages, particularly since, as we have seen, the design must often take account of the fabrication capability of the shipyard, and because the latter must ultimately take responsibility for the performance of the vessel.

There are many independent designers in Canada in relation to the size of the market. The number is around a dozen, excluding the "one man" companies and the shipyards. Only a few of these are involved in technology development and are prepared or equipped to invest in research and development.

Designers may need to initiate studies to look at new concepts (vessel configurations) or materials or to meet new operational requirements. In addition designers to-day are concerned about the "Producibility" and" cost effectiveness" of ship structures.

In recent years some Canadian shipyards have begun to build complete, integrated companies that include design and engineering capabilities, either through take-overs, mergers or internal growth. This has increased the competition among the independent designers, who see the execution of research as a means of maintaining a technical edge, and positioning themselves to compete internationally.

Designers have also generally led the way in peripheral issues in Canada such as establishing the needs for the training of Naval Architects, and the participation in bodies such as the ISSC.

3.2.5 The Shipyards:

Shipyards in Canada - as elsewhere - have operated under rather poor economic conditions for years. With no real National maritime policy, no long term commitments to permit cash flow for re-investment, and potentially uncompetitive rates against overseas, subsidised companies, the industry struggles constantly. There are some 5 major shipbuilding "groups" and a dozen or so smaller yards. The larger "groups" are developing in-house engineering and design capability, threatening the future existence of the Independent designers. These in-house teams are even actively pursuing development work.

The industry is not known for its financial commitment to Research and Development, either in this country or in many places abroad. Where the industry is Nationalised (e.g in Great Britain until a few years ago), research money has been available., and where there is a National commitment to the Industry (e.g. Japan and Germany) technology development has a high priority.

The reluctance of the Yards to invest in research is not, however universal. Several of Canada's biggest yards have invested in manufacturing technology transfer from Japan or elsewhere, and re-invested in capital to become more competitive. When they can see some positive cash flow for a reasonable period ahead - such as when the contract for the CPF started - then they have shown willing to invest some of it in R & D. It is the lack of a long term policy and plan for ship procurement - and therefore lack of guaranteed cash flow, that prevents their participation.

Based on this observation, there is every reason to believe that a focused program of structures R and D that addressed real Canadian problems, and involved the yards in the program decision making, would encourage industry to participate, particularly where they could see their R & D dollars leveraged. Their needs would most likely be in improving the efficiency of fabrication and assembly.

3.2.6 The Regulators:

Canada's regulators are in COGLA and CCG, the former for offshore structures, and the latter for navigable vessels. The CCG role is three-fold - to develop and enforce regulations specifically introduced by the Canadian Government for ships operating in Canadian waters (e.g. the CASPPR), to transcribe and apply international regulations to domestic activities, and to enforce ship safety regulations on vessels designed and built in Canada.

The Regulators must maintain regulations that reflect current design and operational thinking, and preferably put them in a timely fashion to ensure their mandate is met - in most cases pollution avoidance and safety of life at sea. Regulations being associated with safety and reliability, they are by definition tied to the principal motivator for ship structures research as stated in section 3.1.

However the regulators must always account for the economic impact of their regulations, and will constantly be striving for the optimum solution, or the minimum degree of regulation that meets their needs. They will do so in conjunction with operators, designers and builders.

Regulators are not Classification Societies. The latter do not appear in this study since Canada has no indigenous Classification Society. The Classification Societies, of course, do a great deal of structures research. Class societies cannot legislate their rules, and therefore must be cautious of changes, as they operate in a commercial and competitive environment. Regulators can enforce their rules through - in the case of Canada - Act of Parliament. Thus the research needed to support Regulation must be open to scrutiny.

3.2.7 The Executors:

At first glance it might be argued that the 'executors' of research should really not have any R & D "needs". These are the "do-ers" not the "drivers" and they should try to be in a response mode rather than an initiating mode. However, the "doers" are often those most closely linked with the state-of-the-art and therefore with the technology gaps, and so are often in the best position to foresee the needs.

Ship structures researchers in Canada have been covered in the section on Capabilities. There is strong capability in the Defence Department laboratories (DREs) that rarely interfaces with the commercial or non-defence sectors. There is good capability in the universities, who often have trouble responding to time and budgetary requirements, prefer fundamental research and are driven by the need to publish. There is good industry capability in a few small centres. These will deliver practical solutions on time and budget but cannot afford the luxury of side-stepping after interesting discoveries, and relative to Government and universities appear to be expensive.

It is not unreasonable to express the needs of this sector. The executors need to maintain and hone their expertise. They need to continue to execute in order to remain "up to speed", and to continue to support the investment they have made in people and facilities. While it is not suggested that this need should drive the research program, it is reasonable to assume that sponsors will consider the need for continuance of expertise as a contributing factor in program decision-making. Indeed a goal of the major funding agencies should be to maintain the capacity and capability of the Canadian research community.

3.2.8 The Managers:

Research Managers are a fundamental component of the research function, and they too have needs. Their needs include an environment within which to work and plan, a set of global and strategic as well as short term goals, some commitment to medium-to-long-term budgets, and a technical program outline within which to frame their research. Without a focus for the subject, and with no peer review, research quality checks, or a long term budget, there can be no effective management of useful projects.

Unfortunately in Canada most of the above needs have been missing. The history of much of Canada's research in this area shows that it is often driven by individual "champions" who had a specific personal goal or desire, which they were able to pursue in the absence of a stated global program. Such an approach works to a point - and certainly a "champion" is essential - however the problem arises when the lifespan of the champion in the position that initiated the work is less than the research program. The Champion leaves and the work, having no external global mandate, falls aside.

An approach to peer review might be to ensure that projects are managed by a technical committee which includes at least one expert in the field who is not executing the work. Indeed for large scale contract research the concept of placing a separate review contract is attractive. Networking among research managers within the country and abroad would allow discussion of forthcoming projects, and elimination of duplication. To achieve this the research managers themselves will have to establish credibility on the field, and talk to their expert counterparts in other organisations.

Research managers therefore have needs too, and without satisfying these, there will be no skills in this area, and no sound footing on which to base programs.

3.3 CO-ORDINATION NEEDS

3.3.1 Activity Co-ordination:

In Reference 1, Kendrick discusses what he calls "Deficiencies in Present R & D work". These relate to the integration of R & D in the design process, feedback from users, duplication, quality checks, etc. In essence these problems arise from lack of communication and coordination.

To discuss the needs for coordination of activity, the latter can be examined under several headings:

Program Uniqueness
Program Size
Program Quality
Program Utilisation

Uniqueness:

"There are no formal networks and insufficient informal networks to prevent...duplicating effort".

This statement (1) underscores a major problem in Canada. There are instances of duplication not only of projects being undertaken abroad, but also even at home. The "not invented here" syndrome is one with which we are all familiar, and prevails. Ignorance of the work of others is a poor basis for research. Repetition because one does not believe the work of others is perhaps acceptable but must be justified.

Size:

When projects are conceived without full understanding or without a long term committment,there is often a tendency to "nibble" at the problem or at several aspects of problems, with the "small and many" approach. While this cautious approach may safeguard against a major error in direction, it is not an ideal way to tackle major research. Coordination which would allow managers and executors to be more sure of their projected work would permit a bolder approach, and the commitment of larger and longer projects to the solution or real problems in depth. This would also attract the best, most resourceful and most committed researchers.

Quality:

Coordination assists in obtaining an understanding of the state-of- the-art and the global environment in which the work is being undertaken. Through interaction with peers, the quality of the research as specified and performed will be improved.This activity would assist in setting the context for the work. Too little of the research in Canada is subjected to significant peer review. One exception is the work on the CASPPR update. The quality of the work is directly proportional to this effort. Unfortunately we have an atmosphere in which peers are more likely to level destructive criticism in order to gain a perceived competitive edge, than to provide a constructive peer review.

Even the quality of the published work can have an effect on the research activity, and little is done at present to ensure that Canadian research papers are targeted at the appropriate and quality conferences where the necessary peer review and quality exposure will be obtained. Conferences such as those sponsored by the professional societies (SNAME, RINA, IAHR) and in which there is a tradition of severe paper-screening (by peers) and public discussion, are superior venues to those which cater for high volume, (e.g.OTC) and commercial success (e.g. ITC).

Utilisation:

The utilisation of the results of the research continues to be a problem, which can be greatly eased through coordination among all the levels of activity. Kendrick in (1) refers to this as vertical integration. The activity coordination should take place at the three stages: **Planning, Review,** and **Implementation.**

There is a need for a body at which knowledgeable representatives of this technology can interact to review and discuss ship structures programs, and appoint and fund peer review groups, and target specific research areas. By targeting the user group, utilisation of the product should be assured. This is only true, of course if the results reach the user.

3.3.2 Information Dissemination:

This has been a constant source of difficulty in the marine field. In the UK the BSRA produced the "Abstracts" that were widely read. The US SSC produces a bibliography of its structures publications (20). In Canada efforts are made by individual sponsors to inform of work, but it is fragmented and late. Often information is disseminated only due to commercial proponents wishing to promote their activity. Classic cases of reports to, say the ISSC that omitted to recognize large portions of Canadian research are known (see Ref 10).Unfocused publication of papers at seminars and congresses, of which there are a wide variety, further fragments the effort.

A major portion of the ship structures research in Canada is performed for the Navy yet there is little published on this. As an example there are few public documents reporting on the work on the program VAST - over $2.5m worth of development. There must be a greater effort to disseminate knowledge of the Navy activity, perhaps adopting the technique used at TDC where the reports are automatically sent to the organisations that are working in the subject area, and not restricted to Navy venues. (Readers will note the earlier reference to this problem in the UK also). Restrictive rules governing the type of report (Internal Technical Memorandum, Full report, etc), seem to play a part in slowing the process of information reporting from some of the Government laboratories, and it can be many months before a report is listed in CISTI or NTIS. It is likely that much of the Navy material is not classified. If it draws upon information obtained through NATO channels, then a process must be established to identify what is and what is not publishable.

There is a need for a National information dissemination medium - that specifically targets subject areas. This could be through the Marine Advisory Board, who occasionally publish bibliographies of their work (e.g. Reference 21) - or through an arrangement with one of the few Canadian marine technical publications such as Reference 22.

3.3.3 Funding Coordination:

Pooling of funding resources can make R & D dollars go far. At present there are a multitude of funding mechanisms and control. Among funding sources that have been used for ship structures research in Canada are: NSERC, PERD, CCG R & D, TDC Core funding, Various Department capital budgets, and in DND there are separate funds for DMEM and CRAD sponsored R & D. In addition there are few incentives in place for industry contributions. There is certainly scope for duplication of funding.

There is a great deal of ship research that is of common interest to a number of Departments and operators. Some of this has been identified. Such common problems can be funded from a common pool of funds contributed in cash or in kind by those who require the information. This happens informally at present as research managers and contractors seek jointly funded programs. There is a need for a formal mechanism. Such a mechanism would not detract from the ability of a single sponsor to maintain his own special interest programs with his own funds. In addition, it is felt that such effort would not necessarily lead to an increase in government Person Year requirements

3.3.4 Marketing Abroad:

Canada's modest contribution to ship structures research is now being recognised abroad. The additional activity on the ISSC and at ABC 36 and the efforts of various researchers to expose their work is paying off. However, unlike other technical areas, there is no National Focus for the activity. No one organisation or person can be identified as the focal point for structures research in Canada. As an example, the International community knows that Prof. Faulkner, or Prof. Caldwell, or David Chalmers (of MOD(N)) would be focal points for structures research in UK, and that Jeff Beach (DTRC) or Lcdr Pamerlee (USCG/ SSC) would be sources for the US. These focal points are achieved by reputation in the field - not simply by appointment, and in all cases the persons are experts - not administrators.

The lack of such a focus makes it difficult to "sell" our capability abroad, as there appears to be no commitment or focus at home.

There is a need for a coordination body to ensure that our activity is focused, and that publication of our work is given the best and maximum exposure. Not only must this be done, but in the context of overseas activity, it must be of sufficient profile that it is *seen* to be done.The hosting of the ISSC is certainly a start in that direction, but without a focus for the activity inside the country, the credibility of our effort may be questionable.

At a recent seminar on Arctic Transportation (23), several delegates made the point that, while the domestic Arctic resource market may be dormant for 10 to 20 years, the technology that Canada has developed is marketable abroad, provided that there is a National committment from Industry *and Government*. Ship structures research, particularly for operations in ice-covered waters - is a key element of this marketable technology.

3.4 SUMMARY OF NEEDS

This section has discussed in some detail the author's views of the National needs for ship structures research, based on discussion with authorities across the country. The needs have been identified from both the technological viewpoint, and the administrative aspects. There is clearly a need for on-going research in ship structures, justified by the special requirements of some of the Canadian Fleet operators - principally the Government, and by the need to maintain momentum in areas in which we have a reputation and a marketable technology.

PART 4 PROGRAM DEVELOPMENT

4.1 INTRODUCTION:

In this section a program for ship structures research will be developed and presented. This program will be based on the Needs, Priorities and Motivations as discussed in the previous sections, as well as on the Capabilities that are extant in the country.

The priorities are based on the importance of an item of research to a user group, and the breadth of interest in that topic across user groups. Some items (such as blast loading) are of great significance to one user group only. Such an item must be included in discussion of the tota! program, but may not be treated as a National concern due to its single user interest.

Program elements are discussed under the "element" headings as before, based on the ISSC committees. In developing priorities, the assessment is somewhat subjective, and so a number of qualified persons have been approached to review the assessment. In addition, the process chosen to quantify the priorities was relatively insensitive to minor changes in priority or interest from one particular user group.

4.2 DEVELOPING THE INTEREST LEVEL:

Table 4.1 summarises the user needs in the form of a matrix that relates the major structural research issues to the Canadian "User" organisations defined earlier. A weighting factor has been put on these in order to identify the priorities - this factor being the author's assessment based on his discussions. The simplest form of assessing the needs and priorities summed the factors so that the priority is set by both the individual strength of the requirement, and the extent of the interest across the parties concerned. It is used in this section to develop a program to meet the Canadian needs and capabilities.

In the Table, interest levels range from "no entry" - being no interest - thru "1", being low interest to "3" being high interest. Based on this, program priorities have been calculated and are shown in the last column of Table 4.1.**Highest priority items are indicated as "1", etc**

The Table tends to weight the results by the interest of Operators as there are more of these. Designers for example are weighted by only one entry. The "Regulators" are represented only by Coast Guard (Northern and Ship Safety combined). There is no Canadian Classification Society to drive research in Canada. COGLA does regulate the offshore, and as is noted later has an interest in these programs. DFO also regulates fishing vessels - in an operational sense (dimensions and volume). Nevertheless, neither COGLA nor DFO are likely to raise ship structures research issues without going through Coast Guard.

TABLE 4.1 USER INTEREST MATRIX

		THE USERS											
		OPERATORS								REGS	BLDR	DESIG	
		CCG	NAV	DFO	CSA	FVF	CFO	CAN	BSO	CCG	CMIA	NERS	PRIORITY
1 ENVIRONMENT													
WAVES	GULF CORRIDOR				3		1	1		3		2	2
	LAKES				2		1	1		2		1	3
	ARCTIC	2	1				1	2	2	2		1	2
	ATLANTIC	1	2	2	1	1	2	1		1		1	2
	PACIFIC	1	2	1		1	2			1		1	2
ICE	ICE DATA FOR ARCTIC REGIMES	1	1	1		1	1	3	3	3		2	1
	SUB ARCTIC	2	2	2	1	1	2	2		3		1	1
	RIVER	2			2		1	1		1		1	2
	LAKES	1			1		1	1		1		1	3
	ICING	1	1	1		1		1	1	1		1	2
2 LOADS													
	SLAMMING	1	3	1	1			1	1	1		3	2
	GREEN SEA LOADS	1	2	1		2	1			1		2	2
	ICE LOADS (1) Global	2						3	2	3		2	2
	ICE LOADS (2) Local	3	1	1	1	2	2	3	3	3		3	1
	BLAST LOADS		1									2	3
	SHOCK LOADS	1	3					1	1			2	2
	TEMPERATURE LOADS	2	1	1				1	2	2		2	2
	COLLISION/ GROUNDING	1	1	1	2	1	2	1	1	3		2	1
3 STRUCTURAL RESPONSE													
GLOBAL	GLOBAL IN ICE	3		1	2			3	3	3		3	1
	GLOBAL IN SEAS	1	3	1	3			2	1	1		3	1
LOCAL	NEW ICEBRKR SCANTLINGS	3						3	3	3	1	3	1
	LOCAL NON-LINEAR	1	3	1				1	2	3		2	1
	PROGRESSIVE COLLAPSE		3					1	1	1		2	2
	NOISE / VIBRATION	2	3	2			1	1		2		1	2
	RING STIFF CYLINDERS		2								1	1	3
	MONITORING	2	3		3			2	3	3		1	1

KEY | 3= HIGH INTEREST | 1= LOW | BLANK = NONE | 1=TOP 3=LOW

TABLE 4.1 USER INTEREST MATRIX

		OPERATORS								REGS	BLDR	DESIG	
		CCG	NAV	DFO	CSA	FVF	CFO	CAN	BSO	CCG	CMIA	NERS	PRIORITY
4 FATIGUE / FRACTURE													
	FUNDAMENTAL KNOWLEDGE	1	3		1				1	1	1	1	2
	FRACTURE INIT./CNTRL./ARRES	1	3					1	1	1		1	2
	WELDED JOINTS	2	3					1	2	2	2	2	1
	THICK SECTIONS	2	2						2		2	1	2
	DAMAGE TOLERANCE	1	2					1	1	2	2	1	2
	SECONDARY STRESS EFFECTS	1	2	1				1	1	1	1	1	2
5 DESIGN PHILOSOPHY													
	OPTIMISATION	1	1	1			1		2		1	2	2
	RELIABILITY	1	3	1	1	1	1	1	1	1		2	1
	LIMIT STATES	1	2							1		2	3
6 MATERIALS													
	HIGH STRENGTH STEELS	2	2	1	1	1	1	1	2	2	2	2	1
	COMPOSITES	2	3	2		2				1		1	2
	ALUMINIUM ALLOYS	2	0	3		2				1	1	1	2
7 FABRICATION													
	PRODUCIBILITY	1	1		1			1	1		3	3	2
	WELDING TECHNIQUES	2	3	1	1		1		2		3	1	1
	TOLERANCE OF IMPERFECTIONS	1	1					1	1	1	1	1	3
	IMPROVED QUALITY	1	2	1				1	1	1	3	2	2
	ADHESIVES /JOINTING	1	2								1		3
8 DESIGN TOOLS													
	DESIGN OPTIMISATION CODES	1	1	1				1	2	1		3	2
	USER FRIENDLY CODES	2	3	1	1				1	1	2	3	1
	GUIDES/MODEL INSTABILITY		2							2		2	3
	EXPERT SYSTEMS FOR CODE DEV	1								2			3
	E.S FOR F E MESH OPTIMISATION	1	2									1	3
9 NEW VESSEL TYPES													
	LOADS/RESPONSES	1	3	1			1		1	2	1	2	2

4.3 PROGRAM PRIORITIES:

The programs have been set out in priorities in Table 4.2. . In Table 4.2, the number assigned to the program reveals the program element (environment, etc), and assigned priority. There is also appended a code that indicates the degree of National or International significance. The code is as follows:

"C" - A program that addresses unique Canadian problems that has no significance outside Canada and for which it is unlikely there would be much international interest. Such programs may not appear in the International requirements listing. An example would be work associated wih the definiton of the new Ice regimes for the CASPPRegs.

"CI" - A program that is Canadian, but would stimulate interest elsewhere either because of the process or data acquired or because of a similar problem in another country. Ice data in the sub-Arctic would fit this category, as would work on the midship strength of the "80%ers".

"IC" - This program is of International interest, but Canada can contribute especially well either due to its capabilitiy or environment. Temperture loading is a good case of this, as is slamming loads in which we have in the past taken a lead position.

"I" - This program is of International interest and Canada has no particular expertise. Participation in such a program would be of value in establishing International exchanges and reputation.

TABLE 4.2 PROGRAM PRIORITITES

AREA	PRIORITY ONE	PRIORITY TWO	PRI 3/ SPECIALIST
E ENVIRONMENT	E1A ICE DATA FOR REGIMES CI	E2A WAVE STATS COLLECTION CI	
	E1B SUB ARCTIC ICE CONDITION CI	E2B ICE REGIMES ON RIVER C	ES GULF CORRIDOR CSA
		E2C ICING LOADS CI	ES LAKES CSA
L LOADS	L1A LOCAL ICE LOADS CI	L2A GLOBAL ICE LOADS CI	
	L1B COLLISION LOADS IC	L2B SLAMMING IC	
		L2C GREEN SEAS IC	
		L2D SHOCK I	
		L2E TEMPERATURE LOADS IC	LS BLAST NAV
R RESPONSE	R1A GLOBAL HULL RESPONSE I		
	R1B ICEBREAKER SCANTLINGS CI	R2A NOISE RADIATION IC	
	R1C HULL MONITORING CI	R2B STRUCTURAL VIBRATION I	
	R1D LCL. NON LINEAR RESPONSE I	R2C PROGRESSIVE COLLAPSE IC	RS RING STIFFENED CYLINDE NAV
F FATIGUE/FRACTURE	F1A FATIGUE IN WELDS I	F2A FRACTURE INITN/ARREST I	
		F2B DAMAGE TOLERANCE I	
		F2C SECONDARY STRESSES I	
		F2D THICK SECTIONS IC	FS FUNDAMENTAL KNOWLEDG NI
D DESIGN PHILOSPHY	D1A RELIABILITY IC	D2A OPTIMISATION I	
M MATERIALS	M1A HSLA IC	M2A COMPOSITES IC	
		M2B ALUMINIUM ALLOYS CI	
F FABRICATION AND CONSTRUCTION	C1A WELDING TECHN/PROCDRS IC	C2A PRODUCIBILITY CI	
		C2B IMPROVED QUALITY I	
T DESIGN TOOLS	T1A USER FRIENDLY CODES IC	T2A OPTIMISATION CODES IC	TS GUIDES FOR INSTABILITY NAVI
V NEW VESSEL TYPES		V2A WIDE/SHALLOW DRAFT IC	
		V2B SWATH IC	

4.4 STRUCTURES PROGRAM OUTLINE:

A proposed structures research program has been put forward in Figures 4.1 a) to c) for Priority One items, and Figures 4.2 a) and b) for Priority Two items.

Each of the major elements has been broken into program sub-elements. This program of activity is based on the author's assessment of the issues of importance, and the capabilities extant. These sub-elements are not at a detailed enough level to describe a specific research project, but rather at a "generic" level for further development by appropriate experts. While the program has been divided into first and second priority, these priorities will change, with time, opinions and budgets, and so both priority levels have been developed in the same detail.

A code has been used in these figures to identify programs that are of use to a number of interest groups ("common user") programs (shaded boxes) - and those that are of most interest to Coast Guard and the Transportation Development Centre (shaded lead-in). The remainder would fall into special interest - (e.g. Navy) programs.

This overall program is then split into a CCG/TDC proposed program, and a "common user" or national program. Figure 4.3 shows the CCG/TDC priority one program on a five year time frame. Figure 4.4 and 4.5 show the "National" program on the same time frame. The scheduling of these is subjective - but logical, accounting for the current activities, the phasing of budgets, etc. Priority two programs lag those of priority one, and may move into that level in later years.

Some programs -while residing in the ship structures research program - are led by other organisations. AES heads the ice forecasting area, NRC the ice research, and all materials and welding interests are under CANMET. Clearly these bodies may have program plans of their own that interact with this ship program, end their comments and input are invited. However, they are included herein for completeness.

These figures present the author's view of the ship structures research program needed in Canada, meeting the needs, capabilities, budgets, and International concerns.

FIGURE 4.1 PRIORITY ONE PROGRAM

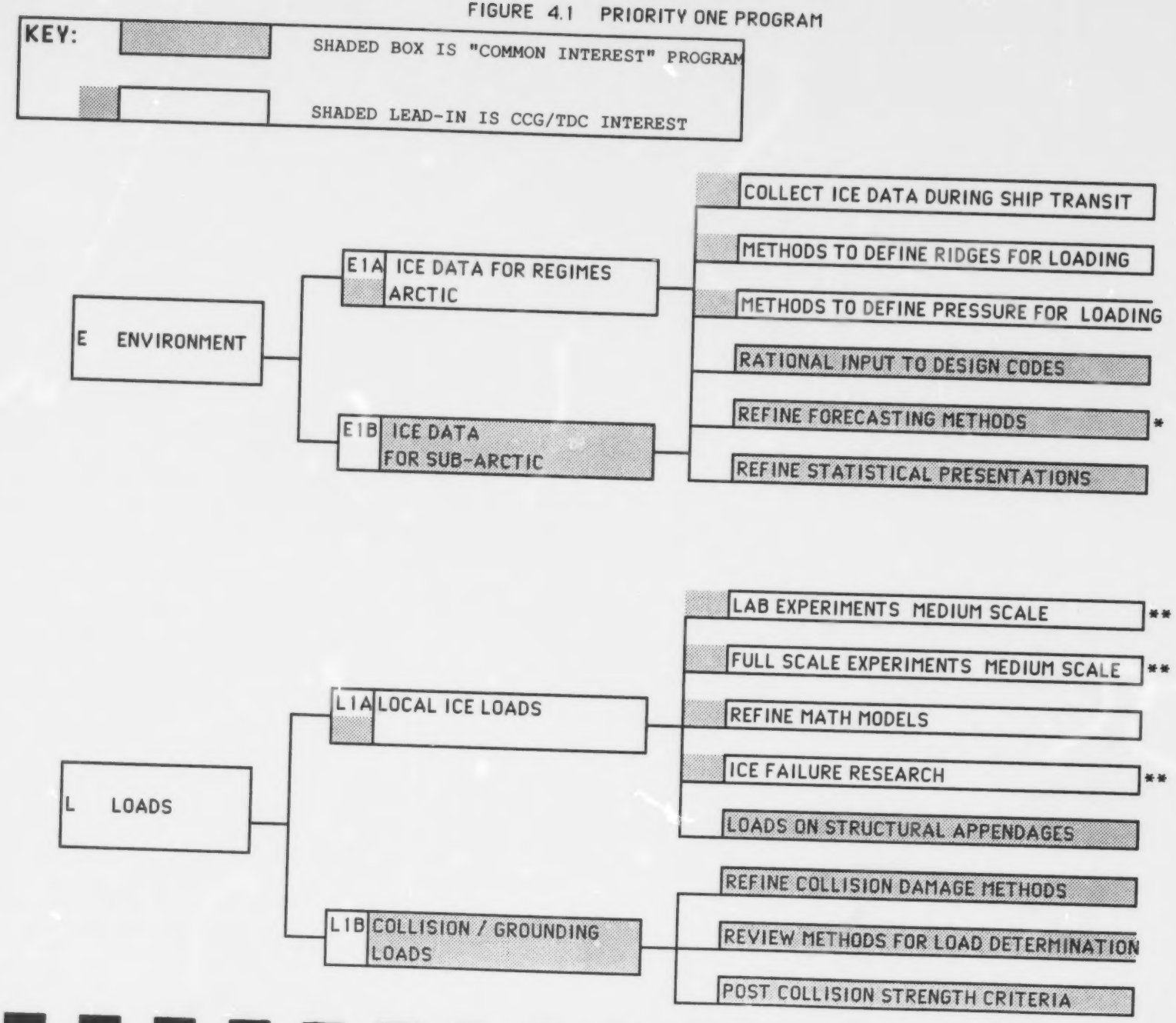

KEY:
SHADED BOX IS "COMMON INTEREST" PROGRAM
SHADED LEAD-IN IS CCG/TDC INTEREST
E ENVIRONMENT
E1A ICE DATA FOR REGIMES ARCTIC
E1B ICE DATA FOR SUB-ARCTIC
COLLECT ICE DATA DURING SHIP TRANSIT
METHODS TO DEFINE RIDGES FOR LOADING
METHODS TO DEFINE PRESSURE FOR LOADING
RATIONAL INPUT TO DESIGN CODES
REFINE FORECASTING METHODS *
REFINE STATISTICAL PRESENTATIONS
L LOADS
L1A LOCAL ICE LOADS
L1B COLLISION / GROUNDING LOADS
LAB EXPERIMENTS MEDIUM SCALE **
FULL SCALE EXPERIMENTS MEDIUM SCALE **
REFINE MATH MODELS
ICE FAILURE RESEARCH **
LOADS ON STRUCTURAL APPENDAGES
REFINE COLLISION DAMAGE METHODS
REVIEW METHODS FOR LOAD DETERMINATION
POST COLLISION STRENGTH CRITERIA

FIGURE 4.1 PRIORITY ONE PROGRAM

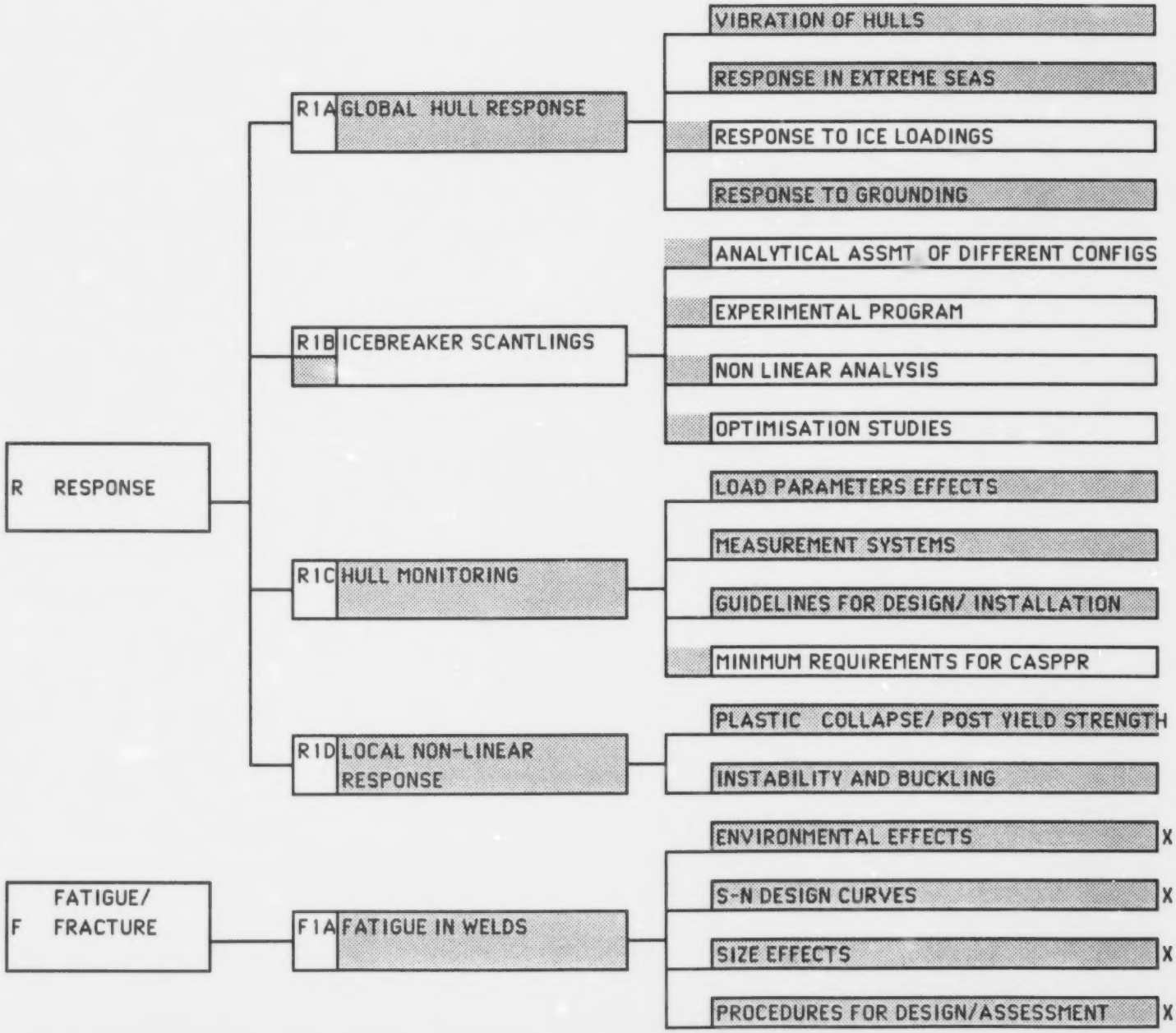


FIGURE 4.1 PRIORITY ONE PROGRAM

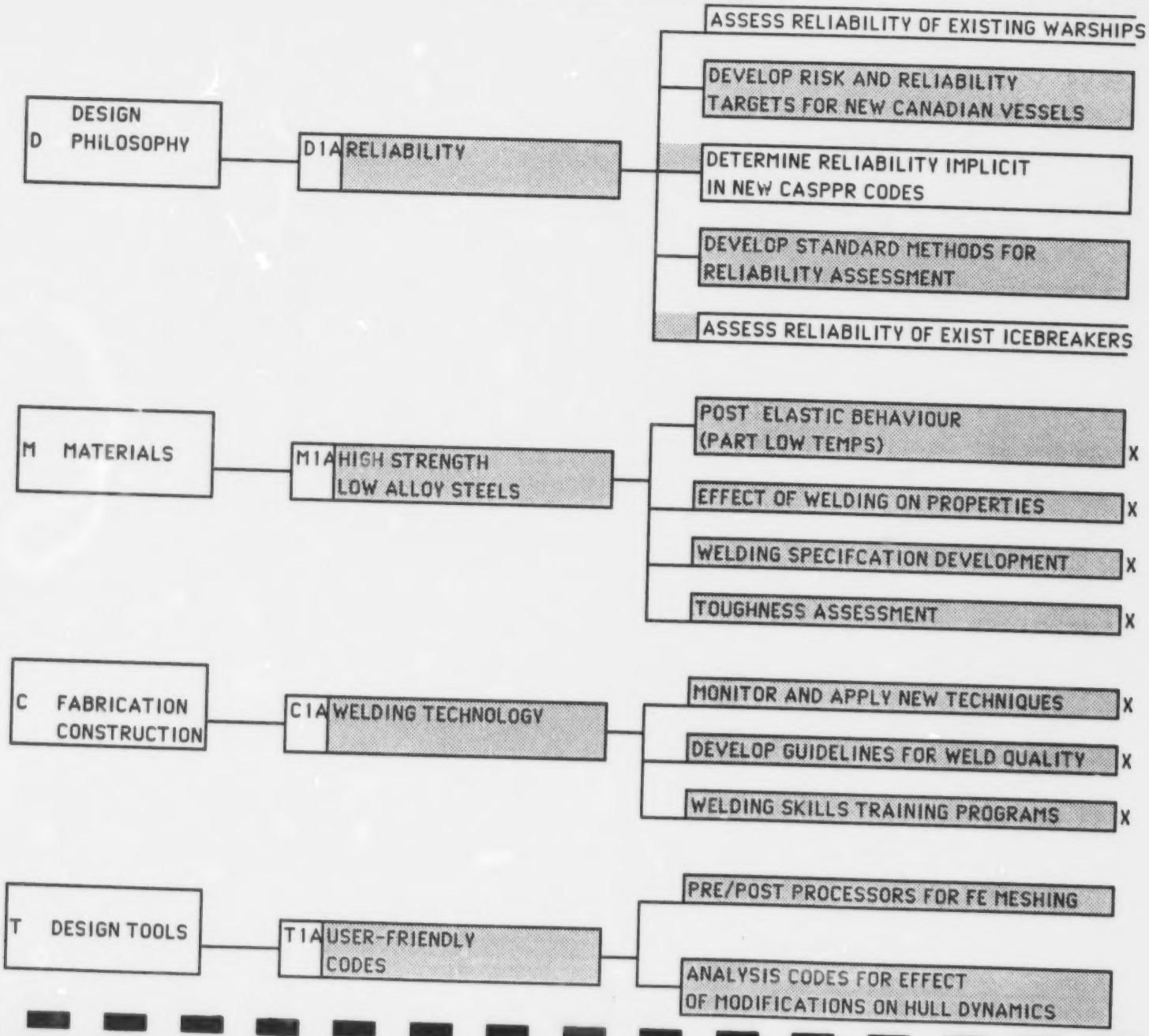

D DESIGN PHILOSOPHY
D1A RELIABILITY
ASSESS RELIABILITY OF EXISTING WARSHIPS
DEVELOP RISK AND RELIABILITY TARGETS FOR NEW CANADIAN VESSELS
DETERMINE RELIABILITY IMPLICIT IN NEW CASPPR CODES
DEVELOP STANDARD METHODS FOR RELIABILITY ASSESSMENT
ASSESS RELIABILITY OF EXIST ICEBREAKERS
M MATERIALS
M1A HIGH STRENGTH LOW ALLOY STEELS
POST ELASTIC BEHAVIOUR (PART LOW TEMPS) X
EFFECT OF WELDING ON PROPERTIES X
WELDING SPECIFCATION DEVELOPMENT X
TOUGHNESS ASSESSMENT X
C FABRICATION CONSTRUCTION
C1A WELDING TECHNOLOGY
MONITOR AND APPLY NEW TECHNIQUES X
DEVELOP GUIDELINES FOR WELD QUALITY X
WELDING SKILLS TRAINING PROGRAMS X
T DESIGN TOOLS
T1A USER-FRIENDLY CODES
PRE/POST PROCESSORS FOR FE MESHING
ANALYSIS CODES FOR EFFECT OF MODIFICATIONS ON HULL DYNAMICS

FIGURE 4.2 PRIORITY TWO PROGRAM

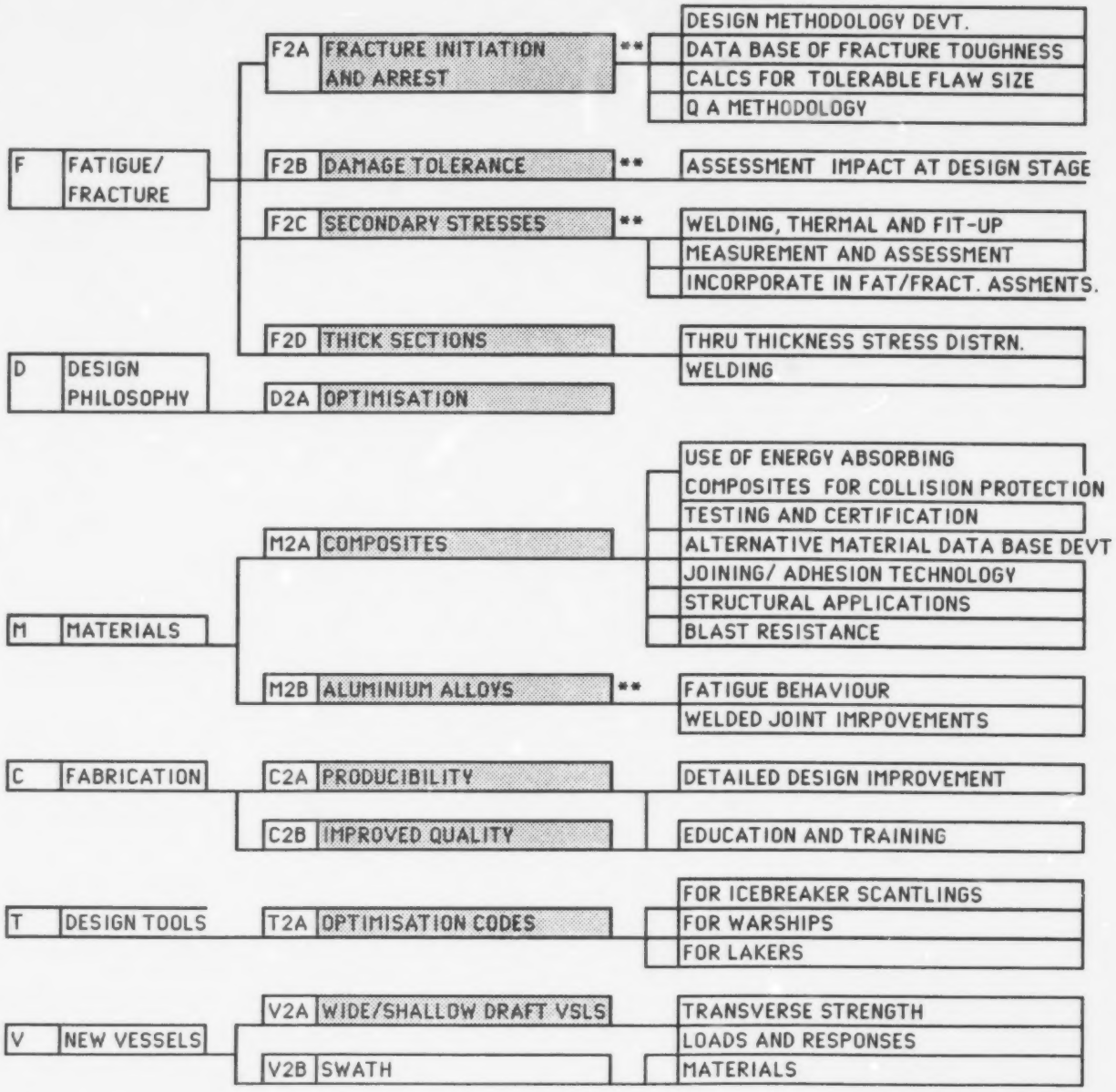


FIGURE 4.2 PRIORITY TWO PROGRAM

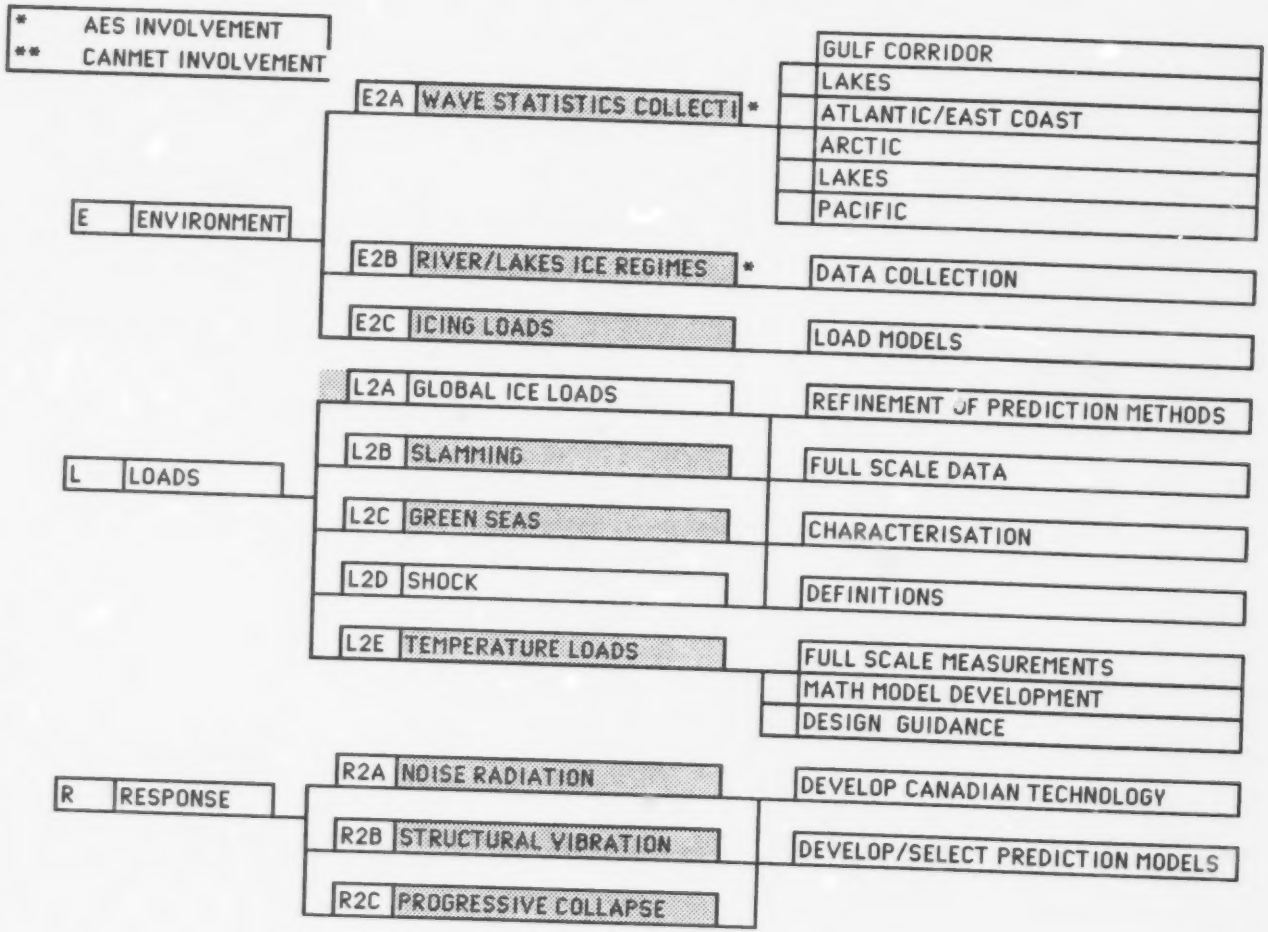
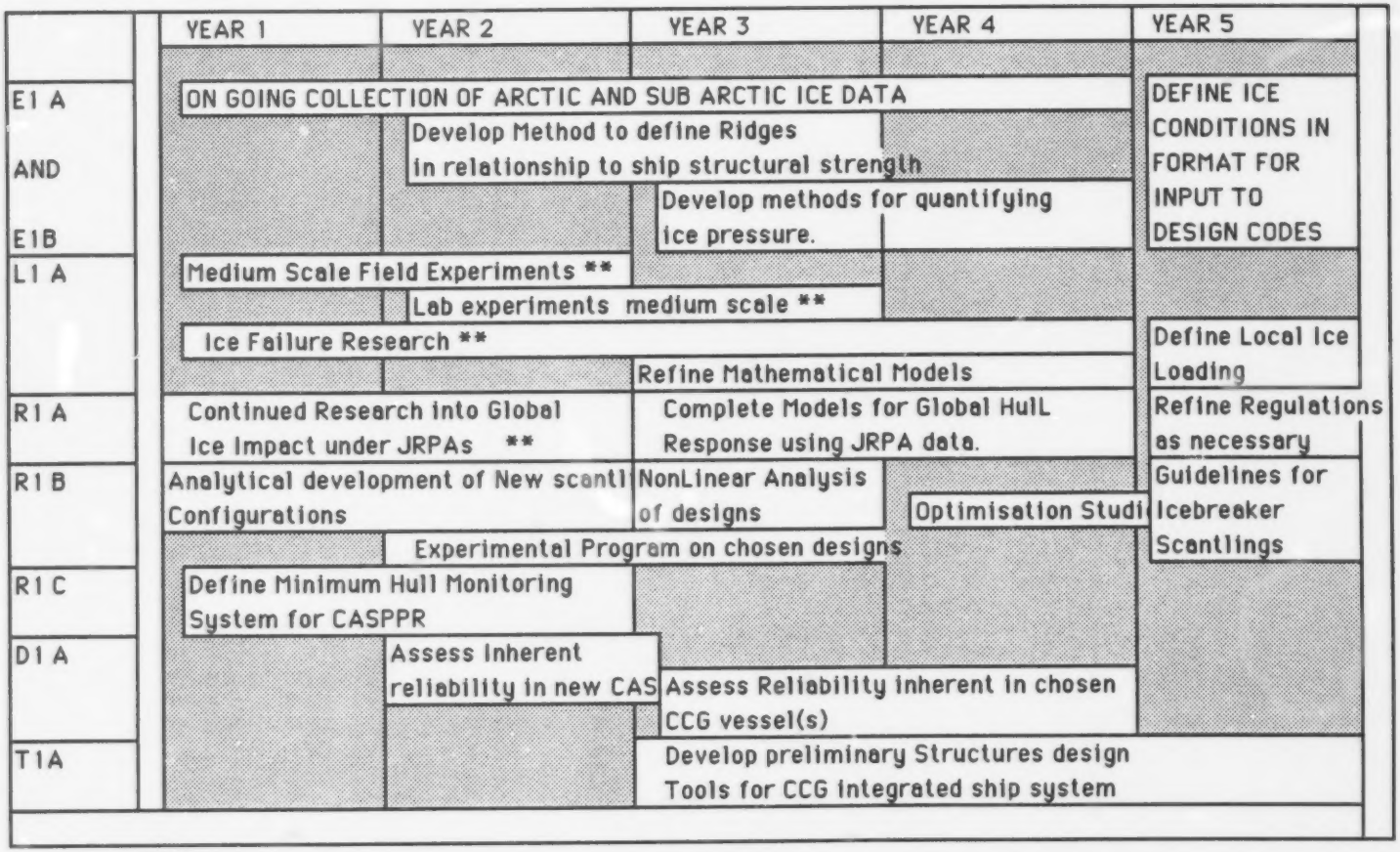


FIGURE 4.3 - TDC / CCG PRIORITY ONE PROGRAM PROPOSALS



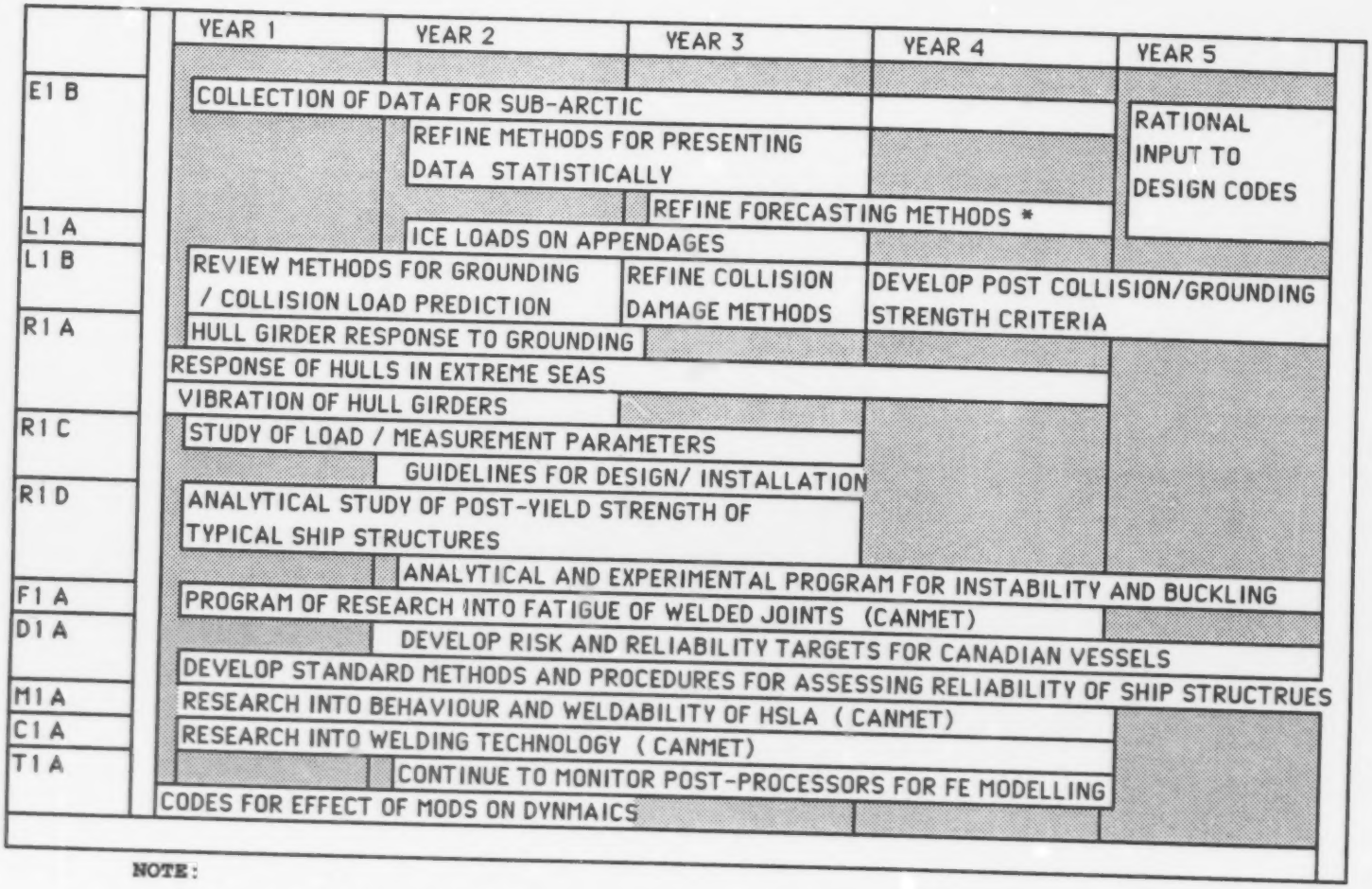
NOTE:

This program includes those ship structures research items that are priority one and have interest only or principally to CCG/TDC.

Other program items of interest to TDC/CCG are also of interest to other users and appear in the proposed common user program.

** These topics are being led by NRC

FIGURE 4.4 NATIONAL PROGRAM - PRIORITY ONE


YEAR 1
YEAR 2
YEAR 3
YEAR 4
YEAR 5
E1 B
COLLECTION OF DATA FOR SUB-ARCTIC
REFINE METHODS FOR PRESENTING DATA STATISTICALLY
REFINE FORECASTING METHODS *
RATIONAL INPUT TO DESIGN CODES
L1 A
ICE LOADS ON APPENDAGES
L1 B
REVIEW METHODS FOR GROUNDING / COLLISION LOAD PREDICTION
REFINE COLLISION DAMAGE METHODS
DEVELOP POST COLLISION/GROUNDING STRENGTH CRITERIA
R1 A
HULL GIRDER RESPONSE TO GROUNDING
RESPONSE OF HULLS IN EXTREME SEAS
VIBRATION OF HULL GIRDERS
R1 C
STUDY OF LOAD / MEASUREMENT PARAMETERS
GUIDELINES FOR DESIGN/ INSTALLATION
R1 D
ANALYTICAL STUDY OF POST-YIELD STRENGTH OF TYPICAL SHIP STRUCTURES
F1 A
ANALYTICAL AND EXPERIMENTAL PROGRAM FOR INSTABILITY AND BUCKLING
D1 A
PROGRAM OF RESEARCH INTO FATIGUE OF WELDED JOINTS (CANMET)
DEVELOP RISK AND RELIABILITY TARGETS FOR CANADIAN VESSELS
M1 A
DEVELOP STANDARD METHODS AND PROCEDURES FOR ASSESSING RELIABILITY OF SHIP STRUCTRUES
C1 A
RESEARCH INTO BEHAVIOUR AND WELDABILITY OF HSLA (CANMET)
T1 A
RESEARCH INTO WELDING TECHNOLOGY (CANMET)
CONTINUE TO MONITOR POST-PROCESSORS FOR FE MODELLING
CODES FOR EFFECT OF MODS ON DYNMAICS

NOTE:

This program includes those ship structures research items that are priority one and have broad interest to users in Canada.

FIGURE 4.5 - NATIONAL PROGRAM - PRIORITY TWO

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	
E2 A	COLLECTION OF WAVE STATISTICS DATA *					
E2 B		COLLECT ICE DATA FOR LAKES AND NAVIGABLE RIVERS				
E2 C				ICING LOADS CODES		
L2 B			COLLECT FULL SCALE SLAMMING DATA			
				CHARACTERISE SLAMMING LOADS		
L2 C		DEFINE GREEN SEAS PROBLEM	COLLECT FULL SCALE DATA			
				CHARACTERISE GREEN SEAS LOADS		
L2 D	FULL SCALE SHIPBOARD MEASUREMENTS					
		MATH MODEL DEVELOPMENT		PRODUCE DESIGN GUIDANCE		
R2 B		DEVELOP/SELECT VIBRATION PREDICTION MODELS				
R2 C		DEVELOP PROCEDURES FOR ANALYSING PROGRESSIVE COLLAPSE OF SHIP STRUCTURES				
F2A		A PROGRAM OF RESEARCH INTO FRACTURE INITIATION AND ARREST, DAMAGE TOLERANCE, ETC LED BY CANMET TAILORED TO SHIP STRUCTRUES.				X
F2 B						
F2 C		PROGRAM FOR DETERMINING SECONDARY STRESS LEVELS IN SHIP STRUCTRUES				
F2 D		THRU THICKNESS STRESS STUDIES		WELDING OF THICK SECTIONS		
D2 A		REVIEW STRUCTURAL OPTIMISATION TECHNIQUES		EVALUATE CODES		
				DEVELOP CRITERIA		
M2 A		EXAMINE USE OF ENERGY ABSORBING COMPOSITES FOR COLLISION PROTECTION				
	DEVELOP ALTERNATIVE MATERIALS DATA BASE			TESTING AND CERTIFICATION STUDIES		
M2 B		ALUMINIUM ALLOY STUDIES LED BY CANMET FATIGUE/FRACTURE				X
C2 A		PRODUCIBILITY STUDIES		DESIGN GUIDELINES		
			DETAILED DESIGN GUIDELINES		EDUCATION	
C2 B			QUALITY IMPROVEMENT STUDIES		TRAINING	X
T2 A		REVIEW AVAILABLE OPTIMISATION CODES				
			COMPARISON STUDIES		RECOMMENDATIONS	
V2A	STUDIES OF TRANSVERSE STRENGTH OF WIDE / SHALLOW VESSELS					

NOTES: This program includes those items that are priority TWO and have broad interest in Canada
Some programs will be led by specific organisations - e.g.
* AES ** NRC X CANMET

4.5 PROGRAM DESCRIPTIONS

4.5.1 Introduction:

For each program specified in the preceding figures and tables, there is a program description and justification. Examples of two of these are given in Figures 4.6 and 4.7, and the remainder are provided in Appendix C. The form for each program also includes the motivating factors as described before, and an indication of whether or not the program is of National or International significance. Where it is possible to do so, a rough order of level of effort is given based on the author's experience. Additional comments on the programs are provided in the following sections, which should be read in conjunction with Appendix C.

4.5.2 Environment:

PROGRAM E1A Arctic Ice Data:

This program must continue as an essential element in the definition of the environment in which Canadian vessels operate, Canadian resources will be extracted and transported and over which Canada has regulatory jurisdiction. Recent efforts to completely redefine ice regimes in terms of the safe operation of vessels, rather than based on fixed geographical zones and times, executed under Coast Guard Northern's direction, are world-leading. The Classification Societies will follow Canada's lead in this area. The knowledge of the ice environment gained by Canadians is greater than any other "Arctic rim" nation.

The activity to date has developed methods of remotely sensing the ice, transcribing the data into ship operations, and defining it in useful terms for designers and regulators. While much progress has been made during the work on the CASPPR update, there remain critical areas for research such as the quantifying of pressure in the ice, and the appropriate way to measure the effect of the presence of ridges. It also remains to continue to collect, assimilate and compare the data with vessel operations, good and bad designs, and refine the process of validation.

While the environmental data collection work has been led by the Atmospheric Environment Service of Environment Canada (AES) CCG will continue to lead in ship matters .

PROJECT NO	C1A	AREA OF RESEARCH	FABRICATION
MOTIVATION	New Materials, Reduced costs		
TITLE	WELDING TECHNOLOGY		
OBJECTIVES	To encourage the improvement of weld performance and fabrication quality in future vessels. To apply new technologies to the Yards to improve productivity and quality.		
JUSTIFICATION	Welds in ships continue to corrode (icebreakers), and be the source of structural defects,(HTS) and distortion. Initial and through-life cost savings can be achieved by improvements in this area. Motivation and training incentives are needed.		
DESCRIPTION	Projects to include refinement and dissemination of information about correct use of high production processes, reduced groove Angles, One sided welding, welding over primers. Define what constitutes good and bad quality Set up skills training programs		
PROGRESS TO DATE	Some of these programs under way for CANMET		
PROP LOE	150K	NATIONAL/INTERNATIONAL	Intl Can
NOTES:	This would be a CANMET sponsored responsibility, and is peripheral to the structures program. Interested parties include industry , DND and CCG		

PROJECT NO	L2C	AREA OF RESEARCH	LOADS
MOTIVATION	Safety, Reliability, reduced pollution risk, ,red in service cost		
TITLE	GREEN SEAS LOADS		
OBJECTIVES	To provide information on the secondary loading due to shipping seas on deck and the resulting effect on overall strength.		
JUSTIFICATION	As ship's hull become lighter with the use of HTS and the drive for improved performance, knowledge of local hull loading is essential to avoid in service damage, and to avoid reduction in overall hull strength due to secondary deformations. However - second priority effort due to international effort in this area.		
DESCRIPTION	To collect full scale and model data on green sea loads, and refine local load prediction methods and design guidance.		
PROGRESS TO DATE	Little work in Canada		
PROP LOE	50K	NATIONAL/INTERNATIONAL	International
NOTES:	The US SSC continues work in this area, which should be monitored and the Canadian Program dovetailed with this.		

PROGRAM E1B Sub-Arctic Ice Data

Clearly the above argument also applies to those regions of ice-covered waters that are not above 60 degrees North. It is in these areas that the majority of ice operations in Canada take place, and in which some oil and gas exploration and production will take place. The most recent ship loss due to ice damage was in this area, and the incidents of damage are largest in these lower latitudes. Continuing to collect and understand the driving forces which create the ice environment as it affects the structural strength of vessels is important. Knowledge requirements for non-Arctic ice conditions are increasing and we can expect this program to become of greater importance.

4.5.3 Loads:

PROGRAM L1A Local Ice Loads:

There are mixed opinions on the value of pursuing knowledge of ice loads in a scientific way. Some experts feel that there are so many variables - many of them affected by the way in which the ship is operated - that a definitive determination of ice loads and pressures will not be achieved. Nevertheless there remains little understanding of local ice pressures and how they vary with contact size, and if ship structural design is to become more rational the load values must be understood. In addition, little has been done on the loading on the appendages ((rudders, skegs, nozzles), and on the loads seen by lightly structured (non-icebreaking) ships. This work could have common interest to many users including the Navy and fishing fleet who operate at the ice edge, and for which some initial work has been started.

PROGRAM L1B Collision /Grounding Loads:

Most ship structural damage arises from collision and/or grounding, and has been pointed out earlier, such incidents often lead to total ship loss, and major pollution. Increased pressure to provide safeguards against pollution will lead to more attention to anti-collision structure (e.g.double bottoms) and improved design for absorbing energy in collisions. Canada can and should contribute here since it enjoys a reputation as an environmentally aware country, has specific "grounding" problems in ice and can utilise the rationale that has been developed for icebreaking tankers (e.g. the APP) to advantage. Current small programs that are exploring the resistance of double sided "Lakers" could lead to the improvement of analysis techniques usable in a broader application. There is also scope for assessing the risk of collision in Canadian waters, using approaches such as were demonstrated for the Arctic Shipping Risk model ASPEN.

4.5.3 Response:

PROGRAM R1A Global Hull Response

This is a major structural research area encompassing response of the whole hull to external excitation, be it wave loads or ice loads, and at a variety of frequencies. There are still major gaps in knowledge in, for example, added mass and damping in ship hull response, in analysis techniques, and in vibration. The SSC has a special program in hull damping estimation. There is concern about the response of vessels such as warships and supply vessels in extreme seas. Canada's particular needs embrace the Lakers (80%ers) and planned large icebreaking tankers, as well as Naval vessels.

PROGRAM R1B Icebreaker Scantlings

This program addresses a specific local response area considered of high significance in Canada, and for which we have a technological lead. Traditional ship structural design scantlings may not be appropriate for efficient icebreaking structures (low fabrication cost and high strength) and research into alternative configurations is underway. On- going work to examine the post-elastic strength of such structures, to examine different configurations to optimise cost/ weight etc, and to meet Canadian manufacturing limitations should be continued.

PROGRAM R1C Hull Monitoring

The principal cry from the International Community and repeated in the SSC program - is for measured feedback of ship structural response. This information has become vital as reliability methods and statistical approaches to design replace empirical methods. Hull response monitoring to obtain strain data has become a major initiative for both seaway and ice induced loading.

Canada has established a reputation in hull monitoring technology through its work on icebreakers and warship slamming. There is a strong industry capability in the three elements required - electronic instrumentation, ship structural analysis, and environmental measurement. There is an opportunity here for maintaining a technology that has export potential. The MV Arctic system should be modified and used to collect wave as well as ice induced responses on an on-going basis. Finally, this all important feedback must be directed to the designers and regulators.

PROGRAM R1D Local Non-linear Response

The behaviour of structure beyond yield,under combined loading and in cases of potential instability (e.g. buckling failure) is still poorly understood and the tools for analysis are complex and not always available to designers. As designs become more rigorous, old margins of safety or "ignorance" become less and an understanding of these more advanced failure processes is essential. The introduction of new ship scantlings and structural configurations requires an ability to examine these more complex forms of failure, and to be aware of such processes as the residual strength in yielded structure, the influence of distortion on collapse under compressive loading, etc. The tools to do this are new and complex, and often in need of validation through experimentation.

4.5.4 Fatigue/ Fracture:

PROGRAM F1A Fatigue in Welds

There remains work to do in determining what factors reduce weld life, and determining the effect of weld size, flaw size, welding procedures, etc. Design and in-service assessment procedures are desirable. The work is of international interest.This program would be led by CANMET, but should be coordinated through the ship interest groups.

4.5.5 Design Philosophy:

PROGRAM D1A Reliability

There is an international effort underway to apply reliability technology and probability concepts to marine structures. The SSC has a five year program underway. This technique accounts for the uncertainty in the predicted loading and the capacity (or strength) of the structure to resist these loads. These uncertainties were previously accounted for by safety margins and experience. There is now a need to design more rationally, to produce more efficient designs whose probable lifespan can be assessed.

In Canada there is a particular need to develop methods to assess the reliability of structures of ageing ships - to assess the risk of failure of the structure. In addition the inherent reliability of new codes (e.g CASPPR) should be assessed. Any contribution here not only addresses a Canadian issue, but contributes to the International effort to produce more effective design processes.

4.5.6 Materials:

PROGRAM M1A High Strength Low Alloy Steels

This program would probably be led by CANMET. The behaviour of these steels in the post-elastic (yield) mode is not clearly identified. In addition data needs to be collected for Canadian produced steels in terms of toughness, weldability, fatigue, corrosion fatigue, etc.

4.5.7 Fabrication/ Construction:

PROGRAM C1A Welding Technology

This is also a CANMET lead, but there are continuing problems with weld quality and welder skills. New processes must be monitored for their appropriate applications to improve quality and reduce production costs.

4.5.8 Design Tools:

PROGRAM T1A User-friendly Codes

Throughout the industry there is a cry for more powerful and friendlier design codes. In structures, most codes are analysis, not design codes, and many are beyond the skills of designers. While it is not proposed to develop complete codes unless this is commercially viable - in which case it should be executed in the Canadian software development industry - it is necessary to build on the skills in the country, and to seek, evaluate and, preferably select common codes.

4.6 PROGRAM DEVELOPMENT

In this section we have presented both a National ship structures program outline, as well as a specific program for CCG/TDC. The program has been described at a moderate level of detail - sufficient it is hoped to identify its relationship wih other International efforts, but loose enough to permit the details to be developed by those more expert in the subject area. In this regard it is considered valuable at this point to discuss some aspects of program development prior to discussing the organisation with which this may be managed.

There are a number of conflicts in the program development between short, - medium-, and long- term research, and between competitive and cooperative research.

Short term "research" will generally be designed to give a *competitive* edge, and is unlikely to be suitable for cooperative research even at National level. It will generally be funded by an individual agent (operator, builder), and the results may not be published. It may also be undertaken for "trouble shooting" purposes, or in the words of CCG Fleet Systems - for "fighting fires ". This type of investigation is not the subject of this study.

The subject of the research herein is Medium and Long term research , which should be able to follow a *cooperative* program in most cases. In Canada, much of the research will be designed to maintain Canada's lead internationally in, say, ice technology, and as such is competitive in an extra-mural sense. It can, and perhaps should, be *cooperative* within the country's boundaries.

The object is to create positive competition among the Canadian practitioners in order to keep them working to achieve better results, but not to let this become destructive and counter-productive. As an example, a contractor executing research for a client will rarely object to another consultant monitoring his work on behalf of that client, provided that there are safeguards in place to prevent the "monitor" using the information to seek further similar work from the client. Such safeguards are largely covered by engineering ethics and good practice, but have been known to break down in Canada and place contractors in serious conflicts.

Another factor to be balanced in the program development is that between Government requirements and those of industry. The program outlined herein is carried to a level of detail that points to the areas of research and indicates some specific project initiatives, but is not of sufficient detail to raise specific research contracts. This is deliberate, as no one person - least of all the author - is qualified to detail such a program. It is suggested that- like that of the SSC in the USA - projects named be initiated in such a way that the executing agencies be given freedom to respond with specific proposals to address the problem. In this way the projects will follow the specific routes that are within the capability of the resources of the country, and the perceived technology approaches of the users and executors of the work. This technique achieves input to Government needs.

In some ways this is similar to the system that existed until recently in several Government Departments, wherein broad program initiatives were published, and unsolicited proposals (UPs) received from industry were then reviewed in light of the Department's objectives. This system, while quite effective, broke down because of the volume of UPs and the fact that the representatives on the various Departmental reviews were not always expert in the area under discussion.

The above are considerations not only for the program content and timeframe, but also for the organisation, which is the subject of the next section.

PART 5 ORGANISATION

5.1 INTRODUCTION

Much of the motivation for this study was driven by the perception that ship structures research in Canada had no focus and no one organisation that could be seen to be the authority on the National effort. While the NRC's Institute for Marine Dynamics may be seen as a focal point for ship *hydrodynamics* research, with no structures programs in- house, this organisation did not fill the position.

As noted before, diminishing research budgets, and changes to priorities dictate more efficient use of R & D resources and an imperative to eliminate unwarranted research, duplication of effort, and to leverage funding to the greatest degree possible. Such efficiency can only be achieved if there is a body that oversees the activity. Hence the thrust towards proposing a form of manageable body that will oversee ship structures research and put into practice some of the desired programs and needs that have been identified.

As a basis for the development of proposals for organisations, a look at two National approaches was taken - those of UK and the USA.

5.2 THE UNITED KINGDOM

The United Kingdom's shipbuilding industry has also fallen on hard times recently, and so has the funding of R and D.

Prior to Nationalisation and subsequent privatisation of the industry, the focus for UK Structures research outside the Navy was the British Ship Research Association (BSRA). They funded and managed research and produced the most useful "Abstracts". The BSRA Ship Structures Committee (until 1979), and other organisations such as the Department of Industry's "Ship and Marine Technology Requirements Board" provided a focus for a National effort, but according to Professor John Caldwell (7) the spirit to-day is one of *competition* not *cooperation.*

A group known as the UK Ship Structures Committee has formed on an informal basis. It meets irregularly, and has no funding authority or process, but at least it brings together the key players to exchange ideas. The Terms of Reference of this group are shown in Figure 5.1. They appear to address a number of issues that would be appropriate to such a committee in Canada. We note that they draw on the ISSC and the US's SSC as a source of linkage with the outside world.

Representation of the Committee included, the Navy (Design and Research representatives), BMT, Lloyd's register, The Royal National Lifeboat Institution, and the UK representative on the ISSC, and Professor at Glasgow University. The Navy chaired the meeting.

In a recent article in "the Naval Architect", the results from an open forum on the subject are summarised. Some of the comments made at that meeting are provided in figure 5.2. They are quite applicable to the Canadian scene. This review of UK Maritime research and development addressed the following questions which are of direct relevance to the issue at hand:(24)

What Resources do we have?
How should coordinated and competitive research be balanced?
How should new technology and Production development be balanced?
Is there benefit in integrating merchant and Navy work?
Can a long term approach be afforded?

FIGURE 5.1

TERMS OF REFERENCE FOR UK

SHIP STRUCTURES COMMITTEE

1 TO REVIEW AREAS IN THE DESIGN, CONSTRUCTION, AND MAINTENANCE OF SURFACE SHIP STRUCTURES AND TO IDENTIFY RESEARCH NEEDS.

2 TO EXCHANGE INFORMATION REGARDING CURRENT STRUCTURES RESEARCH.

3 TO PROVIDE MUTUAL ASSISTANCE TO MEMBERS IN ADVISING ON THE SOLUTION OF CURRENT STRUCTURAL PROBLEMS.

4 TO NOTE ADVANCES IN STRUCTURAL PROCEDURES IN OTHER COUNTRIES, IN PARTICULAR THROUGH THE ISSC AND SSC.

5 TO REVIEW THE FUNCTION, TERMS OF REFERENCE AND MEMBERSHIP OF THE COMMITTEE PERIODICALLY.

FIGURE 5.2

COMMENTS FROM REVIEW OF UK MARINE R AND D

"LITTLE COORDINATED EFFORT"

"THE RINA MIGHT TAKE THE LEAD IN COORDINATING PROGRAMS"

"THE BRITISH "EFFICIENT SHIP" PROJECT FAILED BECAUSE IT WAS TREATED AS DISCRETE NON-INTEGRATED PROJECTS"

"FUTURE R AND D MUST BE RUN BY PRACTITIONERS AND NOT BY ADMINISTRATORS"

"THERE IS A NEED FOR MORE (NAVY) RESEARCH TO BE PUT INTO THE NATIONAL POT SO AS TO ENRICH THE STEW"

"BUILDERS CONCERNS INCLUDE NEW MATERIALS AND MAINTENANCE"

"ENERGY ABSORPTION IN COLLISION IS AN AREA OF CONCERN"

"LONG TERM RESEARCH IS CONDUCTED FOR THE BENEFIT OF THE INDUSTRY AS A WHOLE AND MUST BE MADE AVAILABLE TO THEM"

"WHILE SOME DEFENCE RESEARCH AREAS WERE OF NO INTEREST TO OTHERS, STRUCTURAL STRENGTH, MATERIALS, ETC WERE AND SHOULD BE SHARED"

5.3 THE UNITED STATES OF AMERICA

5.3.1 The Ship Structures Committee:

The United States initiated the Ship Structures Committee (SSC) in 1946, in response to the fracture of numerous welded ships in World War II. It comprised the Navy, Coast Guard (USCG), Maritime Administration, (MarAd), and the American Bureau of Shipping (ABS) . The goals of the SSC were clearly stated in 1952 as shown in Figure 5.3, and the organization is shown in Figure 5.4.

To-day the SSC comprises two additional members - the Military Sealift Command (MSC), and the Minerals Management Service (MMS), the latter being the regulator of offshore activity somewhat equivalent to COGLA in Canada. The USCG sponsors and chairs the committee. The SSC operates at a senior level (The Chairman is a USCG Rear-Admiral), and meets twice a year to resolve overall program and policy issues. The USCG also assigns (and funds) a full-time technical professional officer (usually a Lt Cmdr) to the committee for four years as Secretary to the Committee and its sub-committees.

The technical program and business of the SSC is handled by the Ship Structures Subcommittee (SSSC). This group coordinates the research program, and makes recommendations to the SSC on goals and objectives of the program, priorities, and provides technical evaluation of on-going and completed projects. It will be noted that in this it is guided by a guidance document prepared by the Committee on Marine Structures of the Marine Board, a committee of the National Research Council, whose members are drawn from the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine (25).

The SSSC members include up to four members from each of the above SSC agencies - these being appointed for two years. The chairman of the SSSC rotates among the members and holds his position for three years. In addition specific liaison members may be assigned to the SSSC for a period of two years from any other organizations where they are deemed to be able to contribute technically to the specific current programs and goals of the SSC program. Such organizations as SNAME, The Welding Research Council, and the Naval Architecture departments of the Naval, Coast Guard and Merchant Marine Academies typically provide this liaison.

Finally, the SSSC establishes Project Technical Committees to evaluate proposals and monitor each project. These committees consist of individuals from the SSSC or its liaison members and comprise Government, University *and* consultant experts.

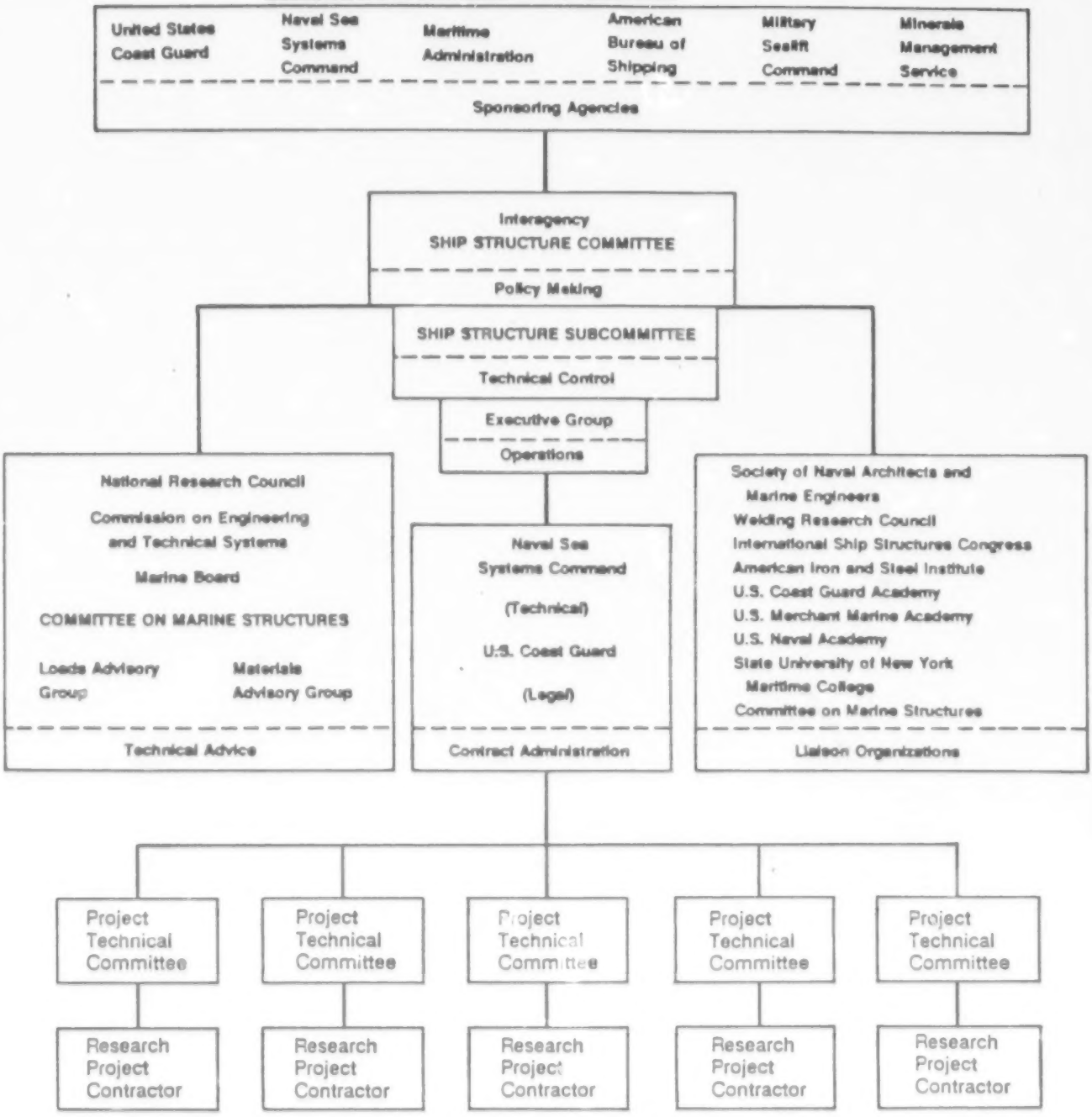
FIGURE 5.3

MANDATE OF THE (US) SHIP STRUCTURES COMMITTEE
1952

"SINCE IT IS NOT KNOWN WHETHER PRESENT REQUIREMENTS AND PRACTICES ARE SUFFICIENT TO PREVENT CRACKING, A LARGE PORTION OF THE RESEARCH PROGRAM SPONSORED BY THE SHIP STRUCTURES COMMITTEE WILL CONTINUE TO BE DIRECTED TOWARD SOLUTION OF THE SHIP FRACTURE PROBLEM. ONCE THIS PROBLEM IS CLEARLY SOLVED, THE RESEARCH ACTIVITY OF THE SHIP STRUCTURE COMMITTEE IS EXPECTED TO BE DIRECTED TOWARD IMPROVING THE GENERAL STRUCTURAL EFFECTIVENESS OF THE SHIP'S HULL AND IN REDUCING BUILDING AND OPERATING COSTS" (WRIGHT, JONASSEN AND ACKER 1952).

FIGURE 5.4

US SSC ORGANISATION CHART



5.3.2 Program Operation:

The guidance document on which the SSC program is based, originates from the Marine Board, and is blessed by the National Research Council. The latter is the principal advisor to the US Government on Science and Technology, and comprises predominantly of distinguished academics and industry leaders. The Marine Board comprises some 18 members and ten staff, the members being drawn from Universities, Government and Industry the latter being both operators and consultants. The Committee on Marine Structures (CMS) is divided into several working groups - "Loads" "Materials", each of which has some 6 to 8 members, drawn from Universities, Government and Industry and chosen for their competence in relevant areas. Note that these members serve as individuals and not as representatives of their employer.

The guidance on the program therefore comes from academics and industry leaders, who best reflect the state-of-the-art, and the needs and capabilities. This guidance is used by the SSC to put together the program. The SSC, as has been seen, is predominantly a Government and Institutional body. The actual administration of contract research is guided by project technical committees comprising Government, University and Industry *specialists*.

Each member organization of the SSC prepares its own short and long-term research needs. There are also meetings with the CMS and SNAME to discuss and refine these. The CMS guidance is then developed drawing on its internal needs, and discussions with others.

The research program is planned over a five year period. The selection and ranking of projects by the CMS - which are described in some detail - is based on the considerations stated in Figure 5.5. The SSC then determines which projects will be funded and when, and with the contractual and administration aid of the Navy and the US Coast Guard issues RFPs and publishes in the Commerce Business Daily. The budget for the SSC has typically been $US500 - 600K per annum.

FIGURE 5.5

CONSIDERATIONS IN THE DEVELOPMENT
OF THE RESEARCH PROGRAM
BY THE
MARINE STRUCTURES COMMITTEE

APPLICABILITY TO THE SSC PROGRAM IN TERMS OF:-
NEEDS, IMMEDIACY, CONTINUITY OF PROGRAM

LIKELIHOOD OF SUCCESSFUL AND MEANINGFUL COMPLETION

IMPORTANCE OF PROJECT TO MARINE STRUCTURES

POTENTIAL FOR SIGNIFICANT RESULTS

WORK NOT BEING DONE ELSEWHERE (INTEGRATION)

5.4 CONSIDERATIONS IN A CANADIAN ORGANIZATION

5.4.1 Lessons from Overseas:

There are lessons to be learned from both the above cases. Canada has, of course, a much smaller marine community, and limited motivation and funding. Nevertheless it would seem possible to create an effective organization for ship structures research - or indeed for other components of ship research in Canada.

> The first lesson comes from one of the MarAd representatives on the SSC (9). He states: "(Among many committees on which I have served), the SSC has been very successful (because there is) :
> -Cooperation, commitment and consistent funding from the member agencies. It practically took a national disaster for this to happen (The cracking of Liberty Ships in WWII noted earlier).
> -Involvement of a prestigious organization (The Marine Board) who were paid to provide their services. We do not depend on volunteer labour for that work.
> -An organization (USCG) willing to provide an employee as Secretary whose job function includes this work"

The budget of the SSC for R and D is not large - even by Canadian standards - at $US500-600K per annum. In fact the current organization is excessive for the level of funding, which has been eroded over the last twenty years. Nevertheless funding *is* found to ensure that there are some full time representatives, and to invite consultants and others to sit on review committees. The result is that the work is well planned, carefully executed, thoroughly monitored and critiqued, and well disseminated.

It is an honour for a consultant to carry out research for the SSC. Compared with a $500K budget, the travel and living costs for a few experts to come to meetings is small. So the first lesson then is that, to ensure commitment, **representation must be funded**. The practice in Canada of relying on volunteer , unpaid input - particularly from Universities and consultants who have minimal budgets, is not a good basis for a successful program. The funding need not be comprehensive - it may be shared - but the gesture is important.

The second lesson comes from a statement made by three separate contacts during this study, and published in the UK document referred to earlier.

"**R & D must be managed by practitioners - not administrators.**"

It is often convenient to place the responsibility for managing R and D under the control of persons who are non-technical, have no knowledge of the field,or who have never conducted R and D. While there is a role for such administration in coordination or funding management, the actual setting of priorities and the managing of the technical program must be in the hands of knowledgeable people, preferably with some R and D experience themselves , and with a good and up-to-date knowledge of the field.

The third lesson to learn is that associated with the prestige associated with the organization, and the effect that this has on the commitment and the cost. Belonging to, or working for, an organization that is effective, has National and perhaps International recognition, and actually can show results for its efforts, is going to attract top-notch people, and invite contributions in the form of funding, and reduced research costs (even from consultants). Achieving this status should be a goal of the Canadian effort.

5.4.2 Setting the Scene in Canada:

Without an Industry Policy or a Marine Policy it is difficult to justify any organization devoted to marine technology matters in Canada. However it is apparent that, with continued expenditure in marine technology-related facilities (IMD, C-FER, etc) the Government *is* concerned about these matters. The formation of a Marine transportation technology group in NRC is also indicative of some need to coordinate activity.

Recent discussions at a workshop on ship manoeuvring at NRC resulted in a virtually unanimous agreement that there should be an NRC Steering Committee or Advisory Committee in this area since the NRC's commitment to marine related facilities was so large. There seems therefore to be a widely held view that some form of coordination of marine programs *is* required.

There are of course several related organizations already in place (see next section) - but their effectiveness varies - and a close inspection may reveal that they do not satisfy some of the lessons noted above.

In proposing a solution, this report will focus on ship structures requirements. However it is apparent that the other technical aspects of marine design also would benefit from some coordination and planning, and that any proposed ship structures committee may have parallels in other areas. Reference can again be made to the recent NRC-sponsored manoeuvring workshop.

The desirable features of an organization to coordinate and manage a National program are shown on the following page. These considerations are taken into account in the development of the proposed organization:

a) Staffed by representatives of all sectors (Government, Institutions, Academia and Industry)

b) At least one position must be a paid, committed resource. (Continuity, commitment)

c) NRC must play a major role. (Prestige, International recognition)

d) Must be predominantly practitioners

e) Must have funding authority

f) Must not detract from individual, single interest programs (e.g. Navy research).

g) Must have strong liaison with other groups who are concerned about operations (needs)

h) Must establish strong communications with all Canadian expertise.

i) Must establish liaison with external (e.g. US) organizations in similar area.

j) Must provide dissemination of information on its work (and preferably other related work).

k) Must be structured (e.g. subcommittees) to allow it to operate at a planning and policy level as well as at a practical level for technical monitoring of projects.

5.5 EXISTING ORGANIZATIONS

It is useful to review briefly some of the relevant existing organizations which may impinge on this subject area.

At the highest level there are two Science and Technology Advisory Groups that advise the highest levels of Government (PM and Cabinet). These are the Science Council of Canada (SCC) and the National Advisory Board on Science and Technology (NABST), the former predominantly representing Academia and the latter Industry. The SCC forms ad hoc subcommittees to investigate specific areas of concern (e.g. (26)). There are also Provincial Science Councils who work with the SSC.

The Advisory Board on Oceans Policy established recently and the Marine Advisory Board are two bodies that comprise top level Industry Government and Institutional representatives, and advise the Ministers of Fisheries and Oceans and Transport respectively. The latter has four regional Boards that concern themselves with particular sectors of the marine industry.

The National Research Council (NRC) and the National Science and Engineering Research Council (NSERC) represent the practitioners to some extent. The former have steering committees and advisory committees from industry in selected areas of technology. None exists for marine matters.

At the practising end of the scale the Defence Department coordinates its ship structures research through the Defence Hydromechanics Research and Development Committee (DHRDC), a body that has representation from both the engineering and research side of the Navy, as well as NRC's Institute of Marine Dynamics (IMD) and a standing invitation to the Transportation Development Centre in Montreal (TDC). Contractors and consultants involved in the programs are excluded from this body, and by way of compensation, there has been a ship structures symposium hosted by the Defence Research Establishment Atlantic at which current program information and progress is reported. Selected contractors are invited if they have programs for DND to report, and there is a closed session on planning and review. The frequency of this symposium is apparently driven by need, and they have been held about 18 months to two years apart.

In addition there are Associations and Group representative bodies such as the Canadian Ship Owners Association (CSA), The Society of Naval Architects and Marine Engineers (SNAME) and the Canadian Institute of Marine Engineers (CIMarE), as well as the Canadian Marine Industry Association (CMIA). These bodies may well have in-house subcommittees to monitor various aspects of marine research, but they are internal only and generally do not play an active role as organisations in National bodies. The CMIA permanent Executive Director sits on the MAB, and a SNAME representative sits on one subcommittee of the predominantly Government run Panel on Energy R and D (PERD) subcommittees. This body plans and funds contract research in support of Energy related issues, is managed by COGLA, and has been responsible for funding a large portion of ship related research - including structures research - in support of the transportation of oil and gas from the Arctic.

5.6 A PROPOSED SOLUTION

5.6.1 Marine Advisory Board Subcommittee:

Following the above analysis, a proposed organization is put forward in figure 5.6. This is, of course, only one of several possibilities. However it is arrived at after some considerable thought and investigation. The following highlights some of these considerations .

A Marine Policy group already exists in the form of the Marine Advisory Board, represented as it is by senior industry and Government persons. This body has four so-called "regional" or "waterway" Boards, which operate at the "practitioners" level. In practice these boards address problems specific to their region. The Boards are Atlantic (dealing with issues such as manoeuvring, simulation, electronic charting, and driven greatly by Marine Atlantic), the Great Lakes, The Pacific (Tug and Barge issues), and the Arctic.

The effectiveness and success of these Boards varies depending on the significance of issues raised, and, of course, the enthusiasm of the chairman and members. With the aid of the full time administrative support of Transport Canada staff, Boards have organized quite useful seminars on topics of concern. Boards form smaller ad hoc committees to examine specific problems or organize projects and seminars. They have been criticised as introducing too much "filtering" of issues raised, and providing insufficient feedback and dissemination of these issues. The attendance is at the attendees' expense in the case of private sector employees, while Government employees claim travel expenses.

There is no Board that deals with marine technical issues at a national level - the very name of the Boards encourages "regional" thinking. Members are invited by Transport Canada, and comprise Universities, operators, consultants and Government.

The proposal would see a new "Board" started - or one of the more dormant existing ones replaced - to deal with the planning and programming of ship structures research. Alternatively, the new Board could take a broader mandate and look at Ship Technology Research as a whole (including manoeuvring, etc) and have ship structures as one of several working groups.

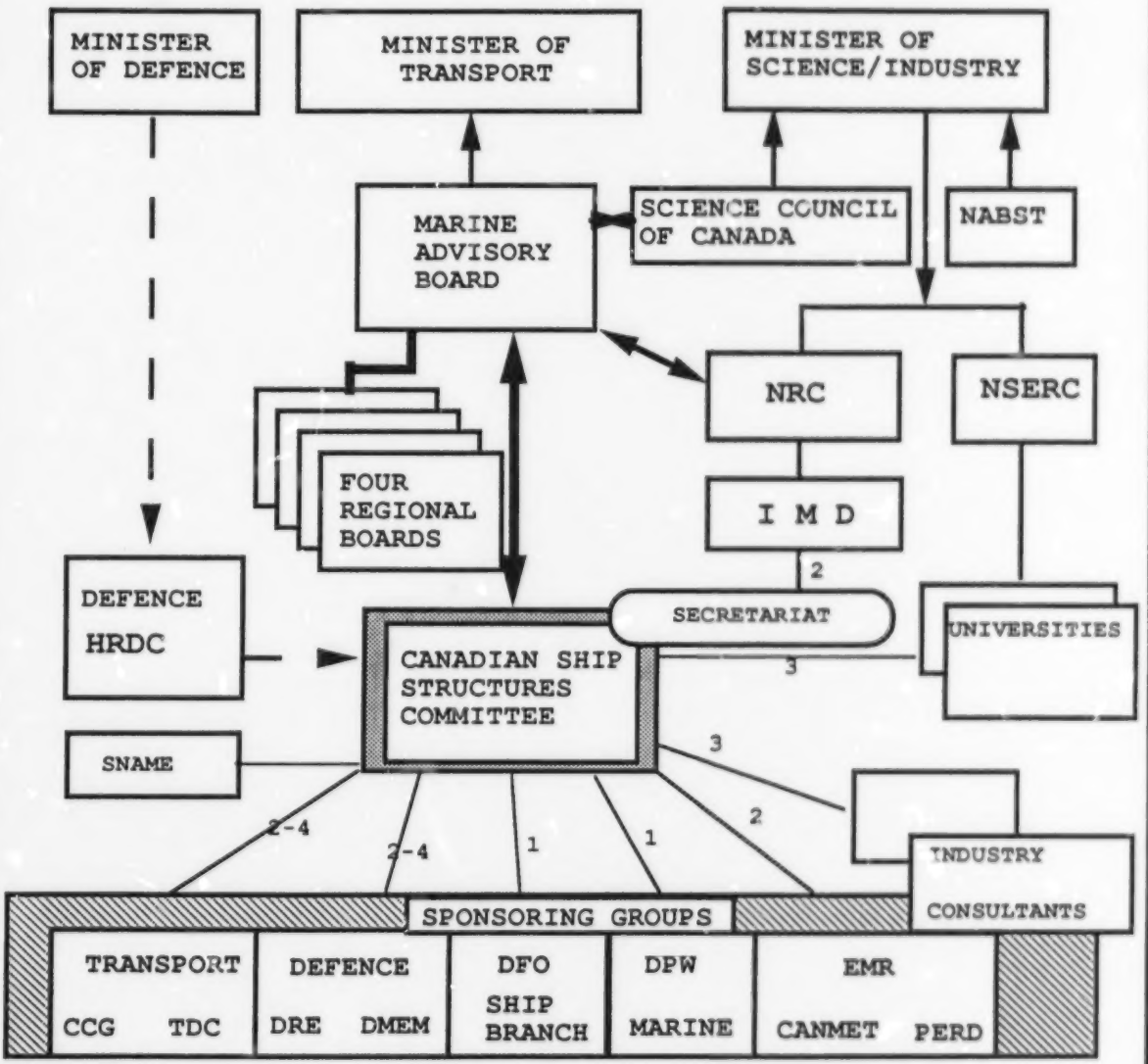
Suggested membership is shown in Figure 5.6 with representation from all the required sectors. The membership would be chosen from experienced and qualified technical people - not administrative staff. The interrelationships of this Committee with the other agencies, subcontractors, liaisons, etc are shown in figure 5.7.

In order to provide the necessary focus, it is proposed that the Committee fund NRC/IMD to provide a permanent secretariat to the Board. In this way IMD is seen to be in the coordinating and focus role, allowing suitable liaison with DHRDC, and DIST Advisory Boards. IMD can then move forward on the Steering Committee of the ISSC with a focal position in Canada's research even if it has no specific in-house programs.

Membership should rotate every two years, and the Chairmanship should rotate also every two years, in a staggered way. the committee should have an R and D plan for ship structures, based on input from several sources (see Figure 5.7). Unlike present Boards, the committee should have clearly set objectives, performance should be measured, and there should be funding - which is addressed later.

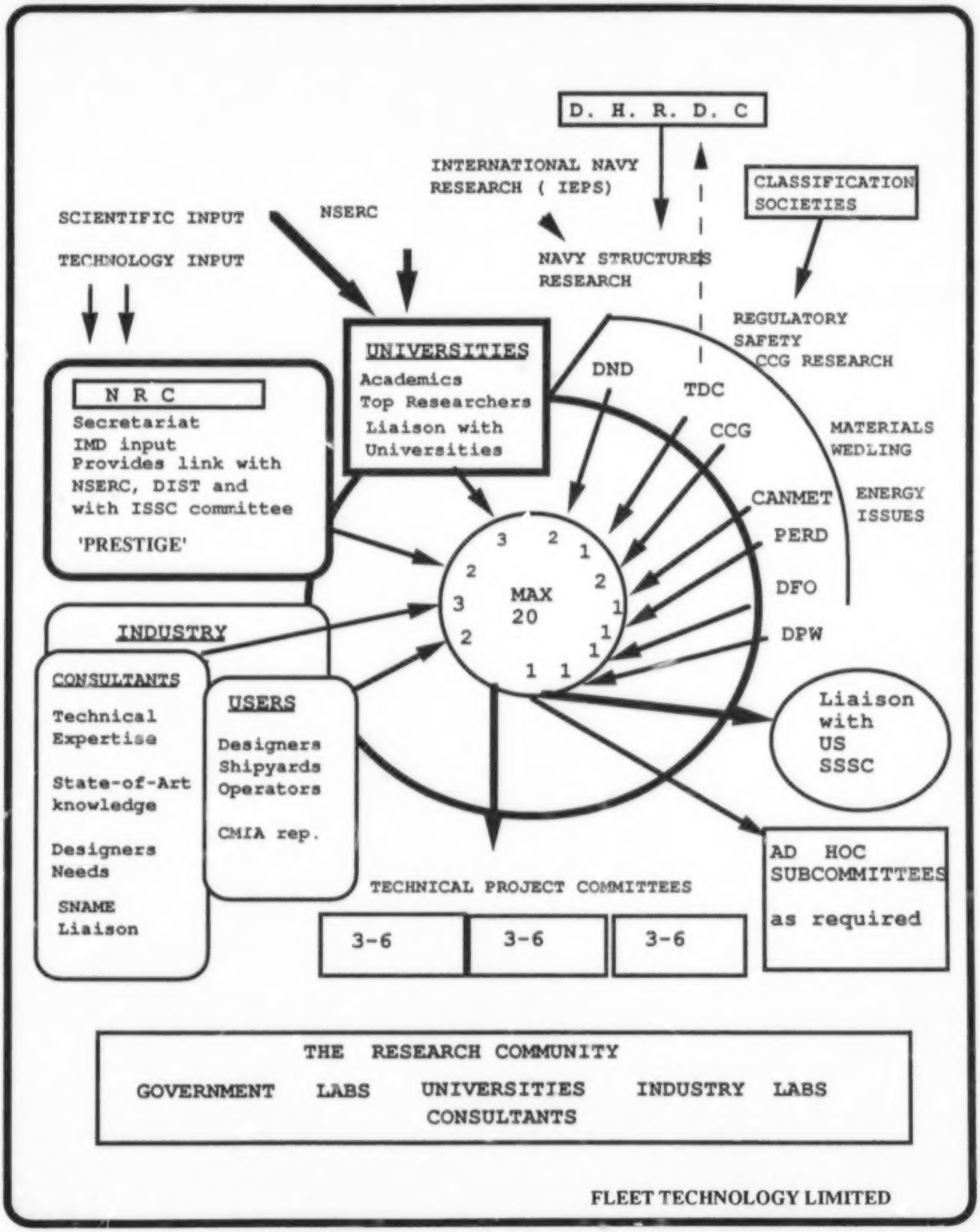
In addition it is proposed that the representatives of the Classification Societies in Canada be invited to attend, as well as SNAME, and a liaison member from the US SSSC.

FIGURE 5.6



FLEET TECHNOLOGY LIMITED

FIGURE 5.7
INTERACTIONS OF COMMITTEE



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5.6.2 The Marine Advisory Board Approach:

The above proposal addresses all the issues and requirements noted earlier. It is focused on the Marine Advisory Board with links to all the other Ministries. Ships and shipping is a Transport issue first and foremost and it is appropriate that the Transport Ministry Board lead.

It is proposed that this initiative be used to re-assess the "MAB Waterway Boards". Perhaps these could be re-organized along technical rather than operational or geographical lines. Perhaps one or two could be supplemented with a Technical Board dealing with all ship research issues, and a series of subcommittees to address structures, manoeuvring, etc. This could tie in with the concurrent concerns about ship manoeuvring activity in Canada. The motivation might be based on the well-recorded fact that some of the Regional Boards devote much of their time to examining why they exist.

If representation is soundly chosen and rotates, and if a degree of funding is obtained, the political / regional issues that gave rise to the current system may well disappear. The rotation of members is a very important element of this organization.

The proposal that a Transport Canada based committee fund NRC to run the body is not new. Coast Guard has "contracted" NRC to manage the ice research projects including the JRPAs with Finland. Such a mechanism must be possible.

5.6.3 Funding:

As has been noted elsewhere, a commitment to funding is essential for the success of this group, whose function is to manage the "common interest" ship structures research program.

A first estimate of the annual funding requirements for the priority one "common" program is $ >1m . However practically speaking it may be better to discuss the funds which sponsors might be able to apply to the committee work. The Sponsoring groups divide into three large multi-interest sponsors, and two or three smaller sponsors. The Transport Department for example is interested as an operator and regulator, and, to some extent as the "national conscience" in marine technology. EMR has several interests as managers of the PERD funds and as the material specialists, and also as COGLA, who as the regulators for the offshore have an interest in this area. DND may be expected to benefit significantly from the work and has interests as designers, researchers and operators. The smaller sponsors may be DFO, DPW,NRC and even occasionally industry. As stated earlier however, the latter will be motivated to address short term concerns, and any sponsorship from industry is likely to be in kind - not money. Ii is important to note however , that many of the industry leaders *do* sponsor the national research effort through self-financed attendance at, and sponsorship of seminars and workshops.

A suggested funding projection is as follows:

TC,DND,EMR	$200K each	$600K
DFO,DPW,NRC	$ 75K each	$225K
Industry	$100K	$100K
Total Annual Budget		**$925K**
Cost of secretariat	$80K	
Cost of travel to meetings	$25K	
Expenses associated with		
Reporting/Information	$20K	$125K
TOTAL available for research		**$800K**

This funding should be reviewed annually in light of results of the group, preferably by an independent reviewer. As a start, the secretariat could be funded to set the process in motion.

5.7 ALTERNATIVES:

5.7.1 NRC:

There has been talk of forming an NRC Advisory or Associate Committee in Marine Technology. With the commitment to the IMD facility it would appear that there is some emphasis on this area, yet there is no advisory group for the NRC initiatives. Presently however the current system of committees is under review. Until the effectiveness of these is established it is not advisable to create a new one. However if we assume that there can be an Advisory committee of experts in marine technology appointed to guide NRC in its endeavours, an alternative ship structures committee organization may be envisaged. This approach has been successful in other areas (for example the Snow and Ice Committee), and would complement the lead that NRC has in the ice research area. The approach ensures that qualified researchers are managing the research program initiatives.

5.7.2 DND:

There has always been scope to extend the DHRDC to become a National Committee. However, based on the reluctance of the Department to communicate its activities to others, such an approach would be doomed to fail in one of the primary objectives unless there was a major shift in attitude. DND has indicated that such a change will not take place as "there is a clear need for Government bodies to meet and talk freely without the hindrance of contractual sensitivity" (27). This response summarises well two of the current problems in Canada - the view of Government that commercial experts are "hindrances" - and the true fact that many commercial practitioners would rather score short term commercial "points" than invest in the long term future of their profession.

The advantage of the DND route would be the international connections that they have, the breadth of activity and capability in the research Laboratories, and the fact that the DHRDC is essentially run by practitioners.

5.7.3 US SSC

During the course of discussions with US Authorities for this project, the suggestion was made that the US SSC would look very favourably on Canada joining that body as a sponsoring agency. In return there would be guarantees that a portion of the research activity would take place in Canada. This is an attractive approach - not necessarily as an alternative, but *in addition* to the proposed new organization. There would be difficulties associated with the transfer of funds, and with deciding who should be represented, and the travel costs would be higher, but the results may be most effective. It is highly recommended that discussions be pursued in this area.

5.8 SUMMARY OF ORGANIZATIONAL RECOMMENDATIONS:

As a result of this study, a strong recommendation is made that a committee be formed under the Marine Advisory Board, but with a contract to NRC/IMD to provide continuity and technical/secretarial services. It is further suggested that NRC not draw on current staff for this, but contract out the function to a suitably qualified and available person.

The committee - provisionally called the **Canadian Ship Structures Committee** - could be additional to, or replace, the current Regional Boards, or could be a sub-committee of a new technical Board to focus all aspects of ship research in Canada. Membership would be technical; and from all sectors, and there would be scope for working groups and project committees to be formed.

Funding would be from member sponsors, and would include funding of committee "overhead". An annual independent review of the results of the sponsored research would be made.

In addition, it is proposed that Transport Canada and DND make a cooperative approach to the USSSC to become sponsoring members of that group.

PART 6 CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS:

The following conclusions are drawn from this study:

1) Canada has specific needs for research into ship structures in support of its on-going and future maritime programs. These needs have been examined, defined and justified based on the demands and requirements of the Canadian fleet operators and the supporting industry.

2) Many of the requirements for ship structures technology in Canada parallel the concerns of the international community, and research programs can and should benefit from, and contribute to, this international community.

3) The Government fleets and the regulatory function of Government have the greatest requirement for ship structures research.

4) For its size and commitment, Canada has a reasonable capability to execute ship structures research, and has established a reputation in, for example, icebreaker structures and structural monitoring systems.

5) Canada has an opportunity to build data bases of full scale ship structural response from available vessels - particularly the MV ARCTIC. The experimental facilities in Canada are not outstanding, but there is an adequate analytical capability.

6) The continuation of a ship structures research activity in Canada can be fully justified based on the operators' and regulators' requirements. but additional justification can be based on the need to maintain the reputation and capability that Canada has built in certain ship structures technology.

7) A program of ship structures research has been developed which addresses the priority concerns of the users and industry in Canada, and which could become the focus of jointly-sponsored research by common interest groups. In addition, there will continue to be ship structures research programs of interest only to a few specialist groups (e.g. Navy, Coast Guard). The common program comprises projects that could be funded at around $800K par annum.

8) Canada's funding resources are such that special care must be taken to minimise repetitive or unwarranted research, particularly that which has been pursued elsewhere.

9) Two major problems with ship structures research in Canada have been coordination of activity, and information dissemination. An organization must be formed that will ensure these activities are improved.

6.2 RECOMMENDATIONS:

The following recommendations are made as a result of this study:

1) Presentation of the results of this study be made to all Departments involved in ship structures research or ship operations in order to seek support for change.

2) An approach be made to officials of the Ministry of Transport to instruct the Marine Advisory Board to examine the possibility of extending its subcommittees to include technical committees. That one such committee should be a committee on ship structures, and that it should be given authority and funding to form a group that will be capable of planning, managing, monitoring and ensuring the quality of a common ship structures research program in Canada.

3) The National Research Council should be contracted by this committee to provide permanent, qualified staff to ensure the necessary continuity and prestige of the committee.

4) That funding for this permanent staff (Secretariat) be approved initially in order to ensure that there is a mechanism for organizing the committee.

5) That formal processes be put in place to ensure that membership of this committee is appropriate, and changes in a prescribed period.

6) That the role of the committee include communication in the form of both dissemination of research results to Canadian users, and the establishment of links with other domestic and foreign committees involved in the area.

7) That Transport Canada and DND approach the US National Science Foundation with the intent to explore the possibility of Canada becoming a sponsoring member of the US Ship Structures Committee

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APPENDIX A

LIST OF CONTACTS

APPENDIX A : LIST OF CONTACTS

Dr D Muggeridge	MUN	Norm Jeffreys	}
		Mary Williams	}IMD
Dave Williams}		Geoff Hubbard	}Lloyd's Register
Bud Streeter }	Marine Atlantic	Ian Burley	} Montreal
Merv Norwood	}	Ian Jones	Saint John Shipbuilding
Claude Desrochers	} MARTEC LTD	Dr Roger Basu }	
Michael Chanaki	}	Bob MacLaren }	MIL SE
Colin Fraser	German Marine Inc	John Bruce	Sandwell Inc
Bob Allen	Robert Allen & Co	Bengt Johansson	AMOCO
Andrew Kendrick, Keith Farrell, Dave Morris			German & Milne Inc.

Coast Guard:		**Department of National Defence**	
Paul Lacroix	Fleet Systems	W R Mc Neilly.	DMEM 3
Jim Connell	Fleet Systems	Lcdr N Mc Cabe	DMEM 3-2
John Mc Callum	Northern	Warren Nethercote	DREA
David Stocks	Northern	David Ritzel	DRES
Jim Archibald	Safety		

C-FER		Don Wight	DFO
J Y Clarke	CMIA	Les McArthur	CSA
Prof Henry HSUIN	TUNS	Prof. H Vaughan	University of BC
Prof. Stafford-Smith	Mc Gill University	Prof S Hutton	University of BC
Prof. Dick Redwood.	Mc Gill University	Prof. A Sherbourne	Waterloo University

TDC Ian Bayly, Mike Stenson, Tom Peirce

UK

Paul Frieze	Advanced Engineering
Professor Doug Faulkner	Glasgow University
Professor John Caldwell	University of Newcastle
Lloyd's Register (Various)	

USA

Donald Liu	ABS New York
Fred Siebold	Mar Ad
Lcdr Mike Parmelee	USCG Secretary, Ship Structure Committee
Jeff Beach	DTRC

FTL Dr Alan Murray, Dr Tarsem Jutla, Dr Lalit Malik, Mick Pates, John Edkins

APPENDIX B

FACILITIES QUESTIONNAIRE

SHIPS' STRUCTURAL TESTING FACILITIES

A QUESTIONNAIRE

1987

Do you have structural testing capabilities to carry out tests at the research and development level to investigate:

1. the strains, stability and collapse loads of metal stiffened panels with initial deformations loaded normally and in-plane; indicate the maximum dimensions of a panel which could be tested in your laboratory;

2. the effective width of metal plates of stiffened panels subjected to both in-plane and normal loads where the plates have initial deformations;

3. the strains, stability and collapse loads of ring stiffened metal cylinders loaded externally, indicate the approximate maximum dimensions of a cylinder which could be tested and the maximum external pressure;

4. the importance of corrosion on the structural behaviour of metal plates and metal connections;

5. the structural behaviour of:

   a. fibre-glass plates with stiffeners;

   b. fibre-glass cylinders;

   c. carbon-fibre tubing;

6. the accuracy with which scaled models can be used to predict the structural behaviour of components of ships;

7. the vibration of parts of ships including the effects of the surrounding fluids; and

8. strains under sea conditions:

   a. using unattended instruments over relatively long periods of time;

   b. using attended instruments during a supervised trial?

As tests involving fatigue are envisaged for some of the above investigations, indicate:

9. the number of loading jacks you possess, their maxima loads in tension and compression, their frequency and stroke.

As a fairly large number of LVDTs and strain gauges may be involved in any one test, indicate:

10. the capability of your data acquisition system giving the number of readings which can be received and the time to receive and store one reading.

As structural tests are often best conducted if their behaviour can be accurately predicted, indicate:

11. the advanced computer software which you can use for such predictions.

12. As tests involving dynamic loading may be required, state whether or not you possess the following equipment:

a. Charpy test instrument;

b. Drop-weight test instrument;

c. Rapid loading pistons;

d. Underwater shock facilities;

e. Shock tube;

f. Shock table.

Please index your replies to the number system used above.

APPENDIX C

PROGRAM DESCRIPTIONS

PROJECT NO	E1A	AREA OF RESEARCH	ENVIRONMENT
MOTIVATION	Safety, Reduced pollution Risk, New vessel Operations, Reduced Cost		
TITLE	ARCTIC ICE REGIMES - DATA COLLECTION / ANALYSIS		
OBJECTIVES	To Define the Canadian Arctic Ice Environment in a realistic way suitable for use in rational ship design and operations.		
JUSTIFICATION	The New CASPPR introduces a new concept in realistic definition of the ice environment in Canada. However more ice data is needed to complete the understanding of ship performance, and for new routes		
DESCRIPTION	Continue to collect ice data for the Canadian Arctic and transcribe this into the ice regime format. Study how this data can be used for ship performance and design - e.g. ridge parameters/frequency.		
PROGRESS TO DATE	CANARTIC has been collecting data and producing atlases of ice. Ice regimes are defined, but data is needed over long term.		
PROP LOE	100K	NATIONAL/INTERNATIONAL	Unique Canadian
NOTES:	AES / CCG / lead		

PROJECT NO	E1B	AREA OF RESEARCH	ENVIRONMENT
MOTIVATION	Safety, Reduced pollution Risk, New vessel Operations, Reduced Cost		
TITLE	Sub Arctic Ice Conditions		
OBJECTIVES	To Define the Canadian Sub-Arctic Ice Environment in a realistic way suitable for use in rational ship design and operations		
JUSTIFICATION	Continued information on the ice conditions around Canada's coast is required for use in design. This includes areas outside CASPPR jurisdiction, and includes Hibernia, etc		
DESCRIPTION	Continue to collect ice data for Canadian Coastal areas and transcribe into the ice regime format. Study how this data can be used for ship performance and design - e.g. ridge parameters/frequency.		
PROGRESS TO DATE	There is significant data available, but it has not been put in a format useful to designers		
PROP LOE	50K	NATIONAL/INTERNATIONAL	Unique Canadian
NOTES:	The data is also of value for the operarion of offshore rigs. This sub arctic data is of interest to Naval operations also.		

PROJECT NO	E2A	AREA OF RESEARCH	ENVIRONMENT
MOTIVATION	Safety, Reduced Pollution, New Operations.,Improved performance		
TITLE	WAVE STATISTICS		
OBJECTIVES	To establish an extensive data base of wave spectra data for Canada's coastal,etc areas - emphasis on directionality.		
JUSTIFICATION	As designers become more rational in design of vessels they require true env. load data. Little is known about extremes, site specifics. Canada has an oceanographic instrument industry to build on.		
DESCRIPTION	Collect site specific data on wave behaviour, currents, etc Develop improved instrumentation and analysis techniques Develop an inernational data base in a designer friendly format.		
PROGRESS TO DATE	Wace statistics collection is on-going but not always relevant. Gulf corridor data is example of site specific design need.		
PROP LOE	150K	NATIONAL/INTERNATIONAL	International
NOTES:			

PROJECT NO	E2B	AREA OF RESEARCH	ENVIRONMENT
MOTIVATION	Safety, Reduced pollution Risk, New vessel Operations, Reduced Cost		
TITLE	RIVER ICE DATA COLLECTION		
OBJECTIVES	To continue to acquire data on ice conditions on Canada's Navigable Rivers and lakes		
JUSTIFICATION	The New CASPPR introduces a new concept in realistic definition of the ice environment in Canada. Ships operating in ice covered rivers will require real data for design checks.		
DESCRIPTION	Continue to collect ice data for Canadian Rivers and transcribe this into the format required by designers.		
PROGRESS TO DATE	Data is being collected but not in a ship trafficability sense		
PROP LOE	40K	NATIONAL/INTERNATIONAL	Unique Canadian
NOTES:	AES lead		

PROJECT NO	E2C	**AREA OF RESEARCH**	ENVIRONMENT
MOTIVATION	Safety,		
TITLE	LOADS DUE TO ICING		
OBJECTIVES	To determine the loads on ship structures and components due to ice accumulaton.		
JUSTIFICATION	Structural loading due to icing remains a little understood area. Information to allow designers to check strength of components subject to icing is needed.		
DESCRIPTION	An experimental program to investigate icing loads and development of prediction models should be made to assist in small boat design.		
PROGRESS TO DATE	Little done in the area as far as structure is concerned Canada is knowledgable on icing.		
PROP LOE	50K	**NATIONAL/INTERNATIONAL**	Canadian/International
NOTES:	Need to examine to see how serious a problem this is first		

PROJECT NO	L1A	**AREA OF RESEARCH**	LOADS
MOTIVATION	Safety, Reduced Pollution, Reduced in service costs.		
TITLE	LOCAL ICE LOADS		
OBJECTIVES	To develop a full understanding of the nature of ice loads /pressures over a full range of areas, geometries, speeds, etc.		
JUSTIFICATION	The loading applied by ice varies with ice type, speed, geometry and is poorly understood for a range of contact areas. This value dictates local scantlings and structural details. This is an area in which Canada has world recognition and should be persued.		
DESCRIPTION	To study the local ice contact areas and pressures over a useful range of areas, under laboratory and field conditions, as well as develop mathematical prediction models for use by designers.		
PROGRESS TO DATE	Work has been done at small and large contact areas but not at medium areas of value in new ship design. There are many variables. While the new CASPPRegs are an improvement, much remains empirical and further investigation and rationalisation is required.		
PROP LOE	$600K	**NATIONAL/INTERNATIONAL**	Can / Intl.
NOTES:	Project is tied in with understanding ice failure processes and with icebreaker scantlings (R1B) NRC leads topic. If Canada stops research at this point it will lose its lead in this area and associated export potential.		

TASK DESCRIPTION

PROJECT NO	L1B	**AREA OF RESEARCH**	LOADS
MOTIVATION	Safety, Reliability, Reduced pollution risk,		
TITLE	COLLISION / GROUNDING LOADS		
OBJECTIVES	To determine the probability and magnitude of loads on ship structures due to collision and/ or grounding and to devise methods to design against and provide post damage residual strength for ships.		
JUSTIFICATION	Increased environmental awareness and recent incidents will lead to pressure for environmentally safe vessels with a degree of post-collision or grounding integrity - particularly in arctic/sub arctic.. DnV has already introduced an environmental Class Regulation. We should focus on Canadian vessels (Lakers, etc)		
DESCRIPTION	To persue a program to project the risk of collision, and to develop methods to design, model and optimise ship structures to reduce risk of pollution, from Canadian vessels, as well as provide post-damage integrity. Program to be geared to specific Canadian vessels, (Lakers, etc) but of value internationally.		
PROGRESS TO DATE	An analysis of Lakers has been made, and Canartic is currently working on an environmentally safe tanker. UBC is working on grounding loads. Current methods for assessment are poor.		
PROP LOE	120K	**NATIONAL/INTERNATIONAL**	International/ Can.
NOTES:	There will be an increased international effort in this area Probability models should be used. Canada's perceived environmentally responsible attitude places it well for some effort here.		

PROJECT NO	L2A	AREA OF RESEARCH	LOADS
MOTIVATION	Safety, Reliability, Reduced Pollution, new Vessel Configurations.		
TITLE	GLOBAL ICE LOADS ON SHIPS HULLS		
OBJECTIVES	To build a full understanding of the characteristics of ice loads acting on a vessel in transit in ice		
JUSTIFICATION	The nature of large scale ice loadings on hulls of icebreakers is not fully understod and there remains a need to persue this to validate simulations, and for extrapolation to larger, different vessels. Ridge loads not known. Interpretation of hull monitoring systems needs work.		
DESCRIPTION	To improve global load prediction methods through validation of simulations by full scale and model tests, as well as ice loading tests in the field. Study ice pressure field loads.		
PROGRESS TO DATE	Much work has been done in this area, and continues under the JRPA A definitive design code for global ice loads is required.		
PROP LOE	200K	NATIONAL/INTERNATIONAL	Canadian / Intl.
NOTES: .	Lead organisation is CCG with interest from TDC DND and commercial (Canartic)_		

PROJECT NO	L2B	**AREA OF RESEARCH**	LOADS
MOTIVATION	Safety, Reliability, reduced pollution risk, ,red in service cost		
TITLE	SLAMMING LOADS		
OBJECTIVES	To provide design guidance for local hydrodynamic loading on hulls due to slamming.		
JUSTIFICATION	As ship's hull become lighter with the use of HTS and the drive for improved performance, knowledge of local hull loading is essential to avoid in service damage, and to avoid reduction in overall hull strength due to secondary deformations. However - second priority effort due to international effort in this area.		
DESCRIPTION	To collect full scale and model data on slamming loads, and refine local load prediction methods and design guidance.		
PROGRESS TO DATE	DND have led the way in Canada with FS, Model and math modelling.		
PROP LOE	50K	**NATIONAL/INTERNATIONAL**	International
NOTES:	The US SSC continues work in this area, which should be monitored and the Canadian Program dovetailed with this. Mostly DND interest		

TASK DESCRIPTION

PROJECT NO	L2C	**AREA OF RESEARCH**	LOADS
MOTIVATION	Safety, Reliability, reduced pollution risk, ,red in service cost		
TITLE	GREEN SEAS LOADS		
OBJECTIVES	To provide information on the secondary loading due to shipping seas on deck and the resulting effect on overall strength.		
JUSTIFICATION	As ship's hull become lighter with the use of HTS and the drive for improved performance, knowledge of local hull loading is essential to avoid in service damage, and to avoid reduction in overall hull strength due to secondary deformations. However - second priority effort due to international effort in this area.		
DESCRIPTION	To collect full scale and model data on green sea loads, and refine local load prediction methods and design guidance.		
PROGRESS TO DATE	Little work in Canada		
PROP LOE	50K	**NATIONAL/INTERNATIONAL**	International
NOTES:	The US SSC continues work in this area, which should be monitored and the Canadian Program dovetailed with this.		

PROJECT NO	L2D	AREA OF RESEARCH	LOADS
MOTIVATION	Safety, Reliability, reduced in service cost		
TITLE	SHOCK LOADS		
OBJECTIVES	To provide information on shock and acceleration loads due to natural and man-made conditions.		
JUSTIFICATION	Shock and vibration in ships remains a problem leading to premature failure of structures, foundations, etc. Icebreakers, warships, etc see shock loads which require definition at the design stage. Canad has poor capability in this area.		
DESCRIPTION	To attain a level of knowledge of shock loads and their effect on structural design.		
PROGRESS TO DATE	Little work in Canada		
PROP LOE	50K	NATIONAL/INTERNATIONAL	International
NOTES:	Not a high priority item in Canada		

PROJECT NO	L2E	AREA OF RESEARCH	LOADS
MOTIVATION	Safety, Reliability, reduced pollution risk, ,red in service cost		
TITLE	TEMPERATURE LOADS		
OBJECTIVES	To determine the loads on ship structures and components due to thermal effects of the environment and cargos		
JUSTIFICATION	Thermal stresses can be as large as mechanical stresses yet are not determined logically. As Safety factors are diminished and the significance of secondary stresses increases, knowledge of these loads is essential. With Canada's environment this is an area where we can contribute to the international arena quite effectively.		
DESCRIPTION	To collect data on typical temperature environments and resulting stresses for vessels in Canada, conduct controlled experiments to measure thermal effects, and review/develop math models that will be used to develop design guidelines and regulatory information.		
PROGRESS TO DATE	TDC and CCG have initiated small data collection programs.		
PROP LOE	75K	NATIONAL/INTERNATIONAL	Canadian - International..
NOTES:	Temperature load data is tied into the low temperature behaviour of HIgh strength steels (M1A), as well as fracture (F1A) Of interest to CCG and TDC		

PROJECT NO	R1A	AREA OF RESEARCH	RESPONSE
MOTIVATION	Safety, Reliability, Reduced Pollution, new Vessel Configurations.		
TITLE	GLOBAL RESPONSE OF THE HULL		
OBJECTIVES	To build a full understanding of the global response of vessels of all types to the full range of environmental loads.		
JUSTIFICATION	Overall hull failure due to environmental loads remains a cause of ship loss. Understanding the effect of dynamic response to dynamic loads is essential. Included in this must be, added mass effects springing, whipping, response to grounding, extreme seas, ice and vibration. Modelling & measurement techniques should be explored.		
DESCRIPTION	Continue to refine the math models that represent global hull response. Perform and refine full scale stress measurements. Develop physical and math modelling techniques for specific responses. to lead to design guidance and regulation.		
PROGRESS TO DATE	Work on Destroyers (Extreme ses) has started. Lakers (80%) have been studied, but work needed on 80%ers. Global response in ice has advanced but lack of knowledge for range of vessels and added mass Work on vibration at UBC being persued.		
PROP LOE	800K	NATIONAL/INTERNATIONAL	International /Can
NOTES:	This program includes work on vibration, added mass, extreme seas response as well as ice loading, 80%ers, etc.		

PROJECT NO	R1B	AREA OF RESEARCH	RESPONSE
MOTIVATION	Safety, Reliability, Reduced cost, new fab tech.		
TITLE	ICEBREAKER SCANTLINGS		
OBJECTIVES	To develop new, economical and easily fabricated scantling systems for icebreaker hulls.		
JUSTIFICATION	Current hull scantlings for icebreakers require excessive welds curvature,etc. They have evolved from normal ship practice. New approaches for thick plated icebreaker structures need examined.		
DESCRIPTION	Design, analysis and testing of new structural systems that improve performance and reduce cost of fabrication as well as utilising Canadian shipyard capability		
PROGRESS TO DATE	A program has started funded by AMOCO, but little work has been done in this area.		
PROP LOE	300K	NATIONAL/INTERNATIONAL	Intl / Can
NOTES:	CCG N interest as well as Beaufort sea Operators.		

PROJECT NO	R1C	AREA OF RESEARCH	RESPONSE
MOTIVATION	Safety, Reliability, .		
TITLE	HULL MONITORING SYSTEMS		
OBJECTIVES	To develop guidelines for the design and installation of hull response monitoring systems		
JUSTIFICATION	The new CASPPRegs require CAC 1,2,3 vessels to have hull monitoring systems. International attention is being paid to such systems leading to reduced insurance costs.There is interest in measuring sea loads,etc. Canada has good, recognised capability in this area.		
DESCRIPTION	To research the factors and requirements for hull monitoring systems for a full range of load types and structures types, and encourage a Canadian product capability.		
PROGRESS TO DATE:	Hull monitoring systems have been fitted in various ships Results are good -- guidelines and specs are needed.		
PROP LOE	$200K	NATIONAL/INTERNATIONAL	Intl / Can
NOTES:	CCG Interest as well as DND		

PROJECT NO	R1D	AREA OF RESEARCH	RESPONSE
MOTIVATION	Safety, Reliability,		
TITLE	LOCAL NON-LINEAR RESPONSE		
OBJECTIVES	To obtain greater understanding of the post-yield collapse mechanisms of ship structures, including suitable modelling and prediction methods, and methods for predicting instability and buckling and utilise this in assessing the ultimate and progression of failure, and develop guidelines in codes such as CAPPR.		
JUSTIFICATION	Design to yield results in heavy structures. For occasional, severe loading plastic deformation may be allowed - yet the methods for modelling are in infancy, and the nature of the response of local structure is not well understood especially progression to ultimate collapse, effect of membrane strain, buckling, etc.		
DESCRIPTION	To investigate the post- yield behaviour of typical ship structures of interest to Canada, in the post yield condition, under combined loadings. Experimental, full scale and analytical approaches to be taken To examine instability of stiffeners, etc for advanced scantlings. To examine a range of scantling configurations.		
PROGRESS TO DATE	Little work in Canada		
PROP LOE	$100K	NATIONAL/INTERNATIONAL	International/Can
NOTES:	A Local response of structure problem of interest to Navy Icebreakers and other vessels subject to high, non-repetitive loads. Of great International significance - must be co-ordinated		

PROJECT NO	R2A	AREA OF RESEARCH	RESPONSE
MOTIVATION	Safety, Reliability,		
TITLE	NOISE RADIATION		
OBJECTIVES	To develop methods and standards to calculate and design for noise radiation through ship structure (and into the surrounding ocean. To create a capability in Canada and remove dependence on overseas expertise.		
JUSTIFICATION	Structure-borne noise can create problems both inboard and outboard of vessels, and will be of increasing environmental importance. It is a complex problem and Canada relies on expertise from abroad at present in what is, on occasions, a sensitive issue.		
DESCRIPTION	To investigate and develop/acquire capability and tools for evaluating noise (and vibration) paths in ship structures with a view to reducing these, and providing design guidelines.		
PROGRESS TO DATE	DND has worked in this area with overseas specialists.		
PROP LOE	$100K	NATIONAL/INTERNATIONAL	Canadian/Internl.
NOTES:	Of interest to Navy and for icenreakers in terms of effect of radiated noise on environment.		

PROJECT NO	R2B	**AREA OF RESEARCH**	RESPONSE
MOTIVATION	Safety, Reliability, Reduced Costs.		
TITLE	STRUCTURAL VIBRATION		
OBJECTIVES	To develop methods and standards to calculate and design against local vibratory response of structure. To understand the mechanisms, ampliofication, excitations, etc. To encourage a Canadian Capability.		
JUSTIFICATION	Structural vibration contrinues to lead to equipment and structural failure and reduced performance. icebreakers, and fast powerful vessels (ferries, warships) are prone. Design methods and software are required as well as better application of known techniques.		
DESCRIPTION	To investigate and develop/acquire capability and tools for evaluating vibration in ship structures with a view to reducing these, and providing design guidelines.		
PROGRESS TO DATE	DND has worked in this area with overseas specialists.		
PROP LOE	80K	**NATIONAL/INTERNATIONAL**	Canadian/Interntl.
NOTES:	Of interest to Navy , ferry operatros and icebreakers. radiated noise on environment.		

PROJECT NO	R2C	AREA OF RESEARCH	RESPONSE
MOTIVATION	Reliability, Safety, Reduced Capital Costs		
TITLE	PROGRESSIVE COLLAPSE		
OBJECTIVES	To investigate the mechanisms of progressive collapse of ship structures with a view to seeking understanding of the process and a basis for the development of "balanced" and economic designs		
JUSTIFICATION	Effective use of steel in ships, particularly weight-sensitive vessels requires an understanding of the contribution made by components of structure to the overall strength, and as a direct result, the progression of failure - to achieve a "balanced" design.		
DESCRIPTION	To perform analytical studies and perhaps experimental work to examine the progression of structrual failure in a typical ship structure, and determine the contribution of structural mechanism of collapse.		
PROGRESS TO DATE	Little.		
PROP LOE	100K	NATIONAL/INTERNATIONAL	Int'l Can
NOTES:	This would be a DND lead. the structures program.		

PROJECT NO	F1A	AREA OF RESEARCH	FATIGUE/ FRACTURE
MOTIVATION	Safety, Reliability, Reduced in-service costs		
TITLE	FATIGUE IN WELDED JOINTS		
OBJECTIVES	To develop practical and workable procedures for the design of joints and welds to resist failure, and to develop methods for in-service assessment of weld life.		
JUSTIFICATION	Fatigue cracking remains a common problem in ship structures, causing potential catastrophic failure and expensive repair. Better design procedures can avoid these failures. Guidance is also needed on action to be taken for cracks found in service.		
DESCRIPTION	Generate S-N curves for typical ship details and develop rules for designers. Develop fracture mechanics methodology for crack growth predictions and in-service monitoring.		
PROGRESS TO DATE	Some of these programs under way for CANMET		
PROP LOE		NATIONAL/INTERNATIONAL	Intl Can
NOTES:	This would be a CANMET sponsored responsibility, and is peripheral to the structures program. Should be pursued with International cooperation.		

PROJECT NO	F2A	**AREA OF RESEARCH**	FRACTURE/FATIGUE
MOTIVATION	Safety, Reliability, reduced costs in service.		
TITLE	FRACTURE INITIATION AND ARREST		
OBJECTIVES	To develop methodologies for avoiding initiation of unstable fractures and/or ensuring their arrest.		
JUSTIFICATION	Brittle fractures originating from fabrication defects or in-service flaws can lead to catastrophic failure. The propagation of cracks must be avoided and continues to be a problem.		
DESCRIPTION	Develop a workable design methodology for avoiding crack propagation. Generate appropriate materials data bases. Develop calculation methods. Improve design guidance on avoidance of cracks.		
PROGRESS TO DATE	Much has been done yet problems remain (MV Arctic) Message is not getting through.		
PROP LOE	60K	**NATIONAL/INTERNATIONAL**	Intl / Canadian
NOTES:	CCG INTEREST		

PROJECT NO	V2B	AREA OF RESEARCH	NEW VESSEL TYPES
MOTIVATION	New vessel Configs, Safety		
TITLE	STRENGTH OF SWATH VESSELS		
OBJECTIVES	To develop a full understanding of the strength and design of SWATH vessels in anticipation of future acquisitions.		
JUSTIFICATION	CANADA has shown interest in SWATH through the Defence Dept and is now evaluating a SWATH (Small Waterplane Area- Twin Hull) in a hydrographic role. It is likely that SWATH vessels will be in Government service.		
DESCRIPTION	To participate in research into the strength of a new configuration of SWATH Vessel, to understand loadings and responses in Canadian scenarios of operation.		
PROGRESS TO DATE	DREA has had interest for some years and has some codes for design. DFO are currently evaluating a vessel		
PROP LOE	100K	NATIONAL/INTERNATIONAL	Intl / Can.
NOTES:	Of principal interest to DND DFO at present		

PROJECT NO	F2B	AREA OF RESEARCH	FABRICATION
MOTIVATION	Reduced Capital Cost, Reliability, Improved fab techniques		
TITLE	DAMAGE TOLERANCE		
OBJECTIVES	To improve the understanding of the effect of damage or defects (material or structure) on the performance of the as-built structure		
JUSTIFICATION	As designs become rational, stress levels rise and the effect of Fabricstion or in-service imperfections becomes significant. These are not normally allowed for in the design stage.		
DESCRIPTION	To study the effect of damage or imperfections or defects (welds , distortion, cracks) on the actual strength of structures.		
PROGRESS TO DATE	Little known		
PROP LOE	100K	NATIONAL/INTERNATIONAL	Intl / Canadian
NOTES:	Of interest to CANMET, DND, CCG		

PROJECT NO	F2C	AREA OF RESEARCH	FATIGUE/FRACTURE
MOTIVATION	Reduced Servvice Cost, Reliability, Improved fab techniques, Safety		
TITLE	SECONDARY STRESSES		
OBJECTIVES	To Quantify and determine the magnitude of thermal, fit-up and welding stresses and their impact on design.		
JUSTIFICATION	In welded structures, fabrication stresses, welding residuals, and thermal stresses are often the largest components of stress on welded joints and can lead to failure.		
DESCRIPTION	To measrue and assess secondary stresses for typical ship structural To assess how they be redistributed due to in-service loading Develop a data base of these stresses for ship details. Develop guidelines for assessment in-servcie and accounting in design.		
PROGRESS TO DATE	Some measurements have been made		
PROP LOE	50K	NATIONAL/INTERNATIONAL	Canadian/Intl
NOTES:	This is of interest to DND and to the industry		

PROJECT NO	F2D	AREA OF RESEARCH	FATIGUE/FRACTURE
MOTIVATION	Reduced Service Cost, Reliability, Safety		
TITLE	THICK SECTIONS		
OBJECTIVES	To Obtain greater understanding of the structural behaviour of thick steel sections (>1") in terms of their fatigue and fracture properties, pertaining to fabrication, welding, thru thickness performance		
JUSTIFICATION	Thicker section steels are in use in the offshore, pipelines, for ballistic protection and for submarines. Canada's knowledge of fabrication issues - particularly in HSLA is small.		
DESCRIPTION	To execute studies and experimental programs on the material properties - particularly fatigue and fracture for thick sections.		
PROGRESS TO DATE	Some work funded by CANMET on welds, also at C-FER, and DREA.		
PROP LOE	100K	NATIONAL/INTERNATIONAL	International/Can
NOTES:	Of interest to offshore companies and DND		

PROJECT NO	D1A	AREA OF RESEARCH	DESIGN PHILOSOPHY
MOTIVATION	Safety, Reliability, Reduced cost, new vessels		
TITLE	RELIABILITY		
OBJECTIVES	To develop methods for assessing the reliability of ship structures particularly those whose design life has been exceeded.		
JUSTIFICATION	Structures rarely if ever fail in accordance with the current design Techniques for assessing the reliability of ageing structures are being developed and should be applied to Candian vessels as needed.		
DESCRIPTION	To develop an understsanding and analysis methods to allow assessment of the reliability of ship structures, pareticularly those whose expected life has been exceeded.		
PROGRESS TO DATE	DND has started a program to assess the reliability of a warship. USCG has started a program through the SSC - could join if needed.		
PROP LOE	200K	NATIONAL/INTERNATIONAL	Intl Can
NOTES:	DND/CCG lead		

PROJECT NO	D2A	AREA OF RESEARCH	DESIGN PHILOSOPHY
MOTIVATION	Reduced cost, new vessels, improved performance		
TITLE	OPTIMISATION		
OBJECTIVES	To review and adopt techniques for optimising ship structure to minimise costs, improve efficiency, etc.		
JUSTIFICATION	Optimisation of ship structrues leads to more efficient use of steel and reduced costs. As better definitions of service loads,' material properties, etc are achieved, structrues can be configured to meet a pre-set optimum. Programs are being developed.		
DESCRIPTION	To develop an understsanding and analysis methods to allow ship structures to be optimised against a prescribed criteria.		
PROGRESS TO DATE	Techniques are being developed but little is being done in Canada		
PROP LOE	80K	NATIONAL/INTERNATIONAL	Intl Can
NOTES:	Do not propose development of codes as these are becoming available.		

PROJECT NO	M1A	AREA OF RESEARCH	MATERIALS
MOTIVATION	New Materials,IMproved performance, being informed.		
TITLE	HIGH STRENGTH LOW ALLOY STEELS		
OBJECTIVES	To study the welding, corrosion, fatigue life and fracture behaviour of welds in HSLA steels.		
JUSTIFICATION	HSLA steels offer advantages in weight reduction, flexibility in design better toughness, and superior weldability. Performance of welds and materials - particularly at low temperatures and for Canadian produced steels is not fully established.		
DESCRIPTION	Examination of Heat Affected Zones fracture behaviour matching weld metals, weld zone corrosion, and fatigue behaviour toughness and weldability, specification development, and base metal post-yield behaviour need to be studied.		
PROGRESS TO DATE	DND has awardrd a contract to MIL to investigate some aspects of welding HSLA.		
PROP LOE	200K	NATIONAL/INTERNATIONAL	Intl Can
NOTES:			

PROJECT NO	M2A	AREA OF RESEARCH	MATERIALS
MOTIVATION	Reduced in service Cost, Reliability, New materials		
TITLE	COMPOSITES		
OBJECTIVES	To improve our knowledge of the potential and behaviour of composites(polymers, steel, alloys) in the marine environment		
JUSTIFICATION	Composite materials can render weight and other savings when used in ship structrues as well as providing opportuniies for special properties. Their future use is expanding.		
DESCRIPTION	Maintain a program of composite research in the marine field. Develop data bases of alternative materials, testing and certification requirements, and design aids. Provide education.		
PROGRESS TO DATE	A MArine Composites Alliance has been founded as well as centres at AMEC and in the West. Training programs are being offered.		
PROP LOE	300K	NATIONAL/INTERNATIONAL	Intl / Canadian
NOTES:	Of interest to DND (DRES) as well as CCG.		

PROJECT NO	M2B	AREA OF RESEARCH	MATERIALS
MOTIVATION	Reduced in service Cost, Reliability,		
TITLE	ALUMINIUM ALLOYS		
OBJECTIVES	To improve our knowledge of Aluminium alloys in the marine Environment particularly pertaining to fatigue cracking.		
JUSTIFICATION	A number of smaller vessels are constructed in aluminium, as will future advanced craft. The material offers potential in reduced weight increased payload, fuel etc. Excellent corrosion resistance However flaws in welding and limited fatigue life can detract from the attraction.		
DESCRIPTION	To establish a program to develop welding techn ology for flaw-free welds and to study the approaches to improving the fatigue life of the welds.		
PROGRESS TO DATE	Little activity in Canada		
PROP LOE	50K	NATIONAL/INTERNATIONAL	Intl / Canadian
NOTES:	Problem was raised by DFO.		

PROJECT NO	C1A	AREA OF RESEARCH	FABRICATION
MOTIVATION	New Materials, Reduced costs		
TITLE	WELDING TECHNOLOGY		
OBJECTIVES	To encourage the improvement of weld performance and fabrication quality in future vessels. To apply new technologies to the Yards to improve productivity and quality.		
JUSTIFICATION	Welds in ships continue to corrode (icebreakers), and be the source of structural defects,(HTS) and distortion. Initial and through-life cost savings can be achieved by improvements in this area. Motivation and training incentives are needed.		
DESCRIPTION	Projects to include refinement and dissemination of information about correct use of high production processes, reduced groove Angles, One sided welding, welding over primers. Define what constitutes good and bad quality Set up skills training programs		
PROGRESS TO DATE	Some of these programs under way for CANMET		
PROP LOE	150K	NATIONAL/INTERNATIONAL	Intl Can
NOTES:	This would be a CANMET sponsored responsibility, and is peripheral to the structures program. Interested parties include industry , DND and CCG		

PROJECT NO	C2A	AREA OF RESEARCH	FABRICATION
MOTIVATION	Reduced Capital Cost, Reliability, Improved fab techniques		
TITLE	PRODUCIBILITY		
OBJECTIVES	To improve the producibility of ships through rational design techniques and improved design detail. To educate designers and cause cooperation with builders.		
JUSTIFICATION	Designers often sacrifice producibility for other design goals. There is a need for guidelines, integration, and education. Such a program could improve Candian builders' competitiveness.		
DESCRIPTION	To research methods for developing guidelines for the design of producable ships. To review existing codes from a viewpoint of producibility. To involve Yards in this research.		
PROGRESS TO DATE	Little. Some designers are producing easily constructed designs, bbut not at local structrue level.		
PROP LOE	120K	NATIONAL/INTERNATIONAL	Canadian/Intl
NOTES:	could be a TDC lead, interest is with all users plus industry		

PROJECT NO	C2B	**AREA OF RESEARCH**	FABRICATION
MOTIVATION	Reduced Capital Cost, Reliability, Improved fab techniques		
TITLE	IMPROVED QUALITY		
OBJECTIVES	To improve the quality of ship construction with a view to reducing risk of failure and in - service costs		
JUSTIFICATION	Most structural failures which have led to catastrophic failure have been associated with quality of fabrication There is a need to blend design and fabrication goals.		
DESCRIPTION	To research methods for improving ship construction quality, and ensuring that designers produce designs that do not inhibit quality in fabrication and repair.		
PROGRESS TO DATE	None known in Canada		
PROP LOE	50K	**NATIONAL/INTERNATIONAL**	Canadian/Intl
NOTES:	CCSRA lead?		

PROJECT NO	T1A	AREA OF RESEARCH	DESIGN TOOLS
MOTIVATION	Reduced Capital costs, New Configs, becoming informed		
TITLE	USER FRIENDLY CODES		
OBJECTIVES	To make sophisticated design programs which tackle new vessel problems, available to the design community.		
JUSTIFICATION	As ship structures are optimised to reduce costs/improve effcy. sophisticated programs must be made more easily usable by designers in the design process.		
DESCRIPTION	To utilise pockets of Canadian expertise to contribute to the effort to produce easily used design (vis a vis analysis) codes and ensure these are available to the industry		
PROGRESS TO DATE	Some progress on in-house programs, but no major international contribution.		
PROP LOE	150K	NATIONAL/INTERNATIONAL	Intl Can
NOTES:			

PROJECT NO	T2A	**AREA OF RESEARCH**	DESIGN TOOLS
MOTIVATION	Reduced Capital Cost, Reliability, Improved fab techniques		
TITLE	OPTIMISATION CODES		
OBJECTIVES	To persue design codes that lead to optimised structural configursations		
JUSTIFICATION	As structural design becomes rational, factors affecting the performance, fabrication, cost,etc must be balanced. To assist understanding of and methods for optimisation techniques must be used		
DESCRIPTION	To review and acquire, if necessary develop , codes to assist in optimising the structural design of Canadian vessels. To determine what, if any ,tools must be developed domestically.		
PROGRESS TO DATE	Some work is being persued in DND and CCG		
PROP LOE	50K	**NATIONAL/INTERNATIONAL**	Intl / Can.
NOTES:	Some indivduals expressed interest from DND and CCG		

PROJECT NO	V2A	AREA OF RESEARCH	NEW VESSEL TYPES
MOTIVATION	New vessel Configs, Safety		
TITLE	STRENGTH OF LOW DRAFT, WIDE VESSELS		
OBJECTIVES	To investigate the overall strength _ paricularly transverse - of new shallow draft self unloading merchant vessels.		
JUSTIFICATION	Canadian interests in self unloading vessels with restricted draft are high. These vessels are very wide (L:B 5:1) to achieve capacity. There are strength aspects to be investigated. Canadian research could ensure continued interest in this area.		
DESCRIPTION	To participate in research into the strength of a new configuration of self-unloader in support of Canadian initatives in this area abroad.		
PROGRESS TO DATE	Melville Shiping Ltd is working in the area		
PROP LOE	30K	NATIONAL/INTERNATIONAL	Intl / Can.
NOTE:	Melville Shipping Limited has initative in this area.		